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EXPERIMENTS ON VORTICES.

ON the 6th of May, 1884, in the Alameda of the city of Monterey, Mexico, I had an opportunity of observing a remarkable whirlwind, the aspect of which is reproduced in Fig. 3.

Three things fixed my attention, viz.: (1) the vertical

FIG. 1.—APPARATUS FOR THE STUDY OF WHIRLWINDS.

axis of rotation of the vortex; (2) the ascending spirals; and (3) the dust and dry leaves and the objects heavier than the air carried up into the atmosphere. These factors of the observation I have reproduced in the apparatus represented in Fig. 1. In this device we find a central screw, with a vertical axis and ascending spirals. The cylindrical box, A, provided with a nut, imitates the objects heavier than the air that are to ascend around the spirals.

As the whirlwind is formed suddenly, I also, through a winch placed at the upper part of the apparatus, give a gyratory motion, from right to left, to the vertical screw and to the metallic piece, A, which at first remains upon its support beneath. If the winch is arrested at the moment of its greatest velocity, the metallic box, A, will rapidly ascend with force, according to the spirals, as far as to the upper part of the apparatus, at A' (No. 2 of Fig. 1). Now, if, at the moment that the ascent of the box begins after the stoppage of the winch, we move the latter very quickly from left to right, then the velocity of the box's ascent and the force of the impact will increase. Suppress the spiral form of the trajectories, and the box will never rise, however swift be the rotary motion. Suppress also the spiral trajectories of a whirlwind, and the latter will not possess the power to lift bodies that are heavier than the air.

As in this extremely simple apparatus the facts of the experiment agree with the observation of natural phenomena, it appears to me of interest to show what the theoretical idea was that guided me in the construction of it.

If we could determine how objects heavier than the air rise in the atmosphere in the radius of a whirlwind's action, we would know the mechanical secret of the latter, especially if this secret, as I believe, consists in the spiral form of its motions. I have thought that I might designate the apparatus represented in Fig. 1 by the name of "mechanical vortex."

After studying the mechanism of whirlwinds, being desirous of applying the same principles to water, I was led to enter upon an examination of waterspouts. For these experiments, I used the apparatus shown in Fig. 2.

Before explaining the operation of this, it is necessary to recall the characters of an ascending marine waterspout. This is usually characterized by a conical column which rises from the surface of the sea, and by the parabolic form of the shower that it produces. We represent the aspect of this great natural phenomenon in Fig. 4. We find the equivalent of such phenomena in the second apparatus (Fig. 2) that I have constructed. Its arrangement is very simple: To the left, upon the box that the apparatus supports, a clock-work movement actuates the elongated cone that enters the water with which the box is filled. Transmission is obtained by an endless belt that actuates a pulley connected with a simple mechanism that revolves the vertical cone around its axis.

To perform the experiment, we put the cone in place (Fig. 2, No. 2). Upon operating the mechanism, the cone acquires a great rotary velocity, and the water rises in gliding over the inner surface, and, on escaping at the top, forms a parabolic shower (Fig. 2, No. 1).

It seems to me that there is here a true waterspout in miniature, with its distinctive characters.

Let us see, from my point of view, how the phenomenon must take place in nature. The sun heats the air at some point or other of the atmosphere, rarefies it, and causes it to ascend; the air of the surrounding space precipitates itself centripetally; and there the aerial currents come into collision, and the vertical motion is produced precisely at the place where the suction is verified by observation. Then the vortex is formed; invisible if it is of air solely, and visible if terrestrial dust or aqueous vapor or spray appears in its mass.

The generating centrifugal force of the ascending spirals, on meeting at a greater height a feeble resistance in the strata of the atmosphere, spreads out at the upper part of the vortex and gives it its conical form.

The conical part of the apparatus, which I call the "hydraulic vortex," has in reality its lower part formed by the water in which it is immersed. It is, in a manner, a closed tube. The column of air, through the gyratory motion of the tube, rises and causes a rarefaction—the essential factor of every whirlwind and of every marine waterspout.—*Dr. J. M. Ancira, in La Nature.*

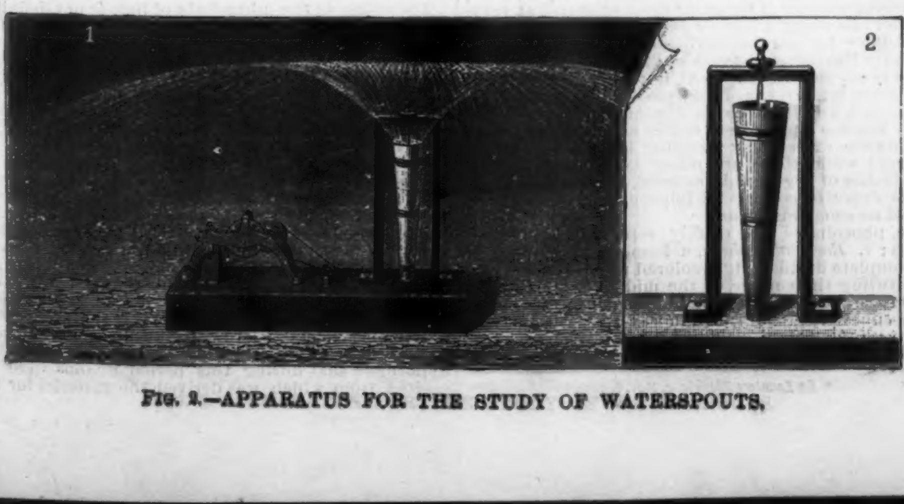


FIG. 2.—APPARATUS FOR THE STUDY OF WATERSPOUTS.

THE DUPLICITY OF α LYRÆ.

AT the meeting of the Royal Astronomical Society on November 14, Mr. A. Fowler exhibited some photographs of the spectrum of α Lyræ which, says *Nature*, indicate that it is a spectroscopic double of the β Aurigæ and ζ Ursæ Majoris type. The photographs were taken with the 10 inch refractor belonging to the Royal College of Science, with two prisms of 7½° each in front of the object glass, and form part of a photographic study of stellar spectra recently commenced at Kensington by Prof. Lockyer with a special object. The evidence of duplicity of this kind of binary star depends upon the fact that when the two components are moving in opposite directions in the line of sight, the lines that are common in their spectra are displaced toward opposite ends of the spectrum in accordance with Doppler's principle, and therefore appear double. When the motion is at right angles to the line of sight, there is, of course, no such displacement, and the lines therefore appear single. Hence, during a complete revolution the lines will twice reach a maximum separation and twice appear single. The principal lines in the spectrum of α Lyræ are due to hydrogen. These do not exhibit a duplication, because the separation is less than their thickness. A variation in their width, however, is very obvious. The K line of calcium is the next strongest, and is sufficiently fine and distinct to render the duplicity very apparent. Fourteen photographs of the spectrum have been taken from October 3 to November 4. The maximum separation of the K line was recorded on October 8 as 7·8 tenth-meters. On October 17, 28, and November 1, 8 P. M., the same line appeared single. At 8·30 P. M. and 10 P. M. on the last named date, the separation was respectively 2·3 and 3·8 tenth-meters. A discussion of the data obtained from all the photographs shows that they are fairly satisfied by assuming a circular orbit, the plane of which passes

FIG. 3.—WHIRLWIND OBSERVED AT THE ALAMEDA OF MONTEREY.

through the sun, and the remarkably short period of revolution of about 24·69 hours. This period does not appear inconsistent with the relative orbital velocity of 370 miles per second indicated by the photograph taken on October 8, and is confirmed by the three photographs taken at short intervals on November 1. If 370 miles per second be taken as the maximum relative orbital velocity, the distance between the components is about 5,000,000 miles. The total mass will therefore be about 22·5 times that of the sun, and as there is no appreciable difference in the intensity of the K lines, the masses of the components are probably about equal. In the case of β Aurigæ and ζ Ursæ Majoris, Prof. Pick-

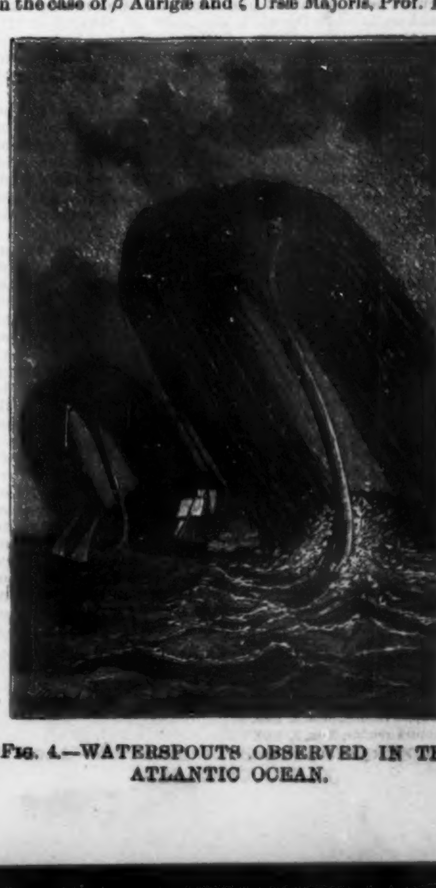


FIG. 4.—WATERSPOUTS OBSERVED IN THE ATLANTIC OCEAN.

ering found respectively periods of 4 and 52 days, and maximum orbital velocities of about 150 and 100 miles per second.

THE REVOLUTION OF THE PLANETS PRODUCED BY THE ELECTRODYNAMIC ACTION OF THE SUN.

By C. V. ZENGER.

ON several occasions since 1878 * I have shown that the astronomical and meteorological phenomena that have been attributed to the action of universal gravitation or of gravity are, on the contrary, easily explained by the electrodynamic theory of the sun—a theory that I proposed in 1878.

Much opposition and many objections were presented to me without any one having endeavored to refute this theory by the only way admissible, that is to say, by properly performed experiments. I proposed to prove by this means, the only sure and conclusive one, that the phenomena of attraction and repulsion observed in the motions of the celestial bodies, in the whirling motions of the atmosphere, and in the seismic motions of our globe can be reproduced by the electrodynamic action of powerful electromagnets, or by the energetic discharges of any electric machine whatever. In 1885, I described the vortical phenomena produced in a bell glass filled with white smoke derived from the combustion of magnesium when a partial vacuum has been produced by an air pump.† From this experiment I deduced the conclusion that the great vortical disturbances of the atmosphere, cyclones, typhoons, and tornadoes, are very probably of electric origin, and that atmospheric electricity is the cause and not the effect of these intense vortical motions.

The periodicity of about thirteen days observed in cyclonic storms, cyclones and typhoons has led me to admit the solar origin of the high electric tensions observed in the upper regions of the terrestrial atmosphere. Having demonstrated the same periodicity ‡ for magnetic storms, whose solar origin is at present generally admitted, and for the northern lights which very often accompany them, I have been led to suspect like periodicity in seismic movements and in volcanic eruptions, which seem to be nothing less than the effect of igneous vortices formed under the electrodynamic influence of the sun upon the fluid core of the earth; and, in acting, these storms of the fluid ocean produce in their turn a counter effect upon the solidified and rugose crust of the globe.

This periodicity once proved, all the great movements of the atmosphere and of the interior of the globe are found to be governed by an identical recurrence, to wit, the duration of a half revolution of the sun. These phenomena manifest their electric origin, and it is seen that they are produced by electromagnetic induction and by the direct discharge of electricity between the sun and the earth through interplanetary space.

During the universal exposition of 1889, I demonstrated, with my apparatus with three electromagnets acting upon a hollow copper sphere suspended by a silk thread and rotated by the torsion of the latter, that it is possible, under the action of one, two or three poles, to reproduce the orbicular motions of the planets around the sun, circular, elliptical or more or less eccentric, and that it is even possible to reproduce the phenomena of planetary perturbations.

It is with this apparatus that we can solve the problems of the action of three bodies § and figure the orbits thus described.

In order to fill the gaps of my electrodynamic theory of the motions in the solar system, it still remained for me to imitate the revolution of the planets around their axis through electrodynamic action. Now I succeeded in this ‖ by the revolving of a glass globe under the influence of the discharges of a Wimshurst electric machine. In the direction of its vertical diameter, I deformed a hollow, silvered glass sphere, such as is found in commerce, and placed a steel axis in the conical cavity thus obtained.

The axis is fixed upon a wooden support and insulated from the table by a hollow glass cylinder. Upon placing the hollow sphere between the balls of the exciter of a Wimshurst machine in such a way that the said balls shall be at a distance of several centimeters from the surface of the hollow sphere (this being indispensable in order to prevent the formation of sparks), we obtain a rotation of the sphere around its vertical axis.

In this way the right line that joins the centers of the balls of the exciter does not pass through the center of the glass sphere. When we begin to turn the winch of the electric machine, the sphere begins to revolve, and its motion becomes thoroughly uniform when the winch is turned uniformly. The faster it is turned, the quicker becomes the revolution. This rotary motion may thus be made to obey the hand of the experimenter.

This revolution of a hollow sphere under the influence of the two poles of an electric machine surprisingly confirms the views as to the origin of celestial motions that I have expressed in the note: "Etudes astrophilographiques." ¶ It is very probable that the sun behaves like a huge dynamo-electric machine acting upon the bodies situated in its vicinity, as are the different planets of its system. The energy of the sun manifests itself, then, by determining *all the motions* in interplanetary space, on the surface and in the interior of the planets. *The revolutions of these latter, like those of comets and meteorites, are due solely to the motions resulting from the action of the dynamic poles of this enormous source of energy.* But these reproductions of terrestrial cyclonic movements and of orbicular and rotary planetary motions through electricity would not seem to me yet conclusive enough to permit of replacing by electrodynamic laws those of universal gravitation, were it not possible to reproduce likewise, through electrodynamic action, the phenomena of activity observed on the surface of the sun. This I have very recently been enabled to accomplish through electric discharges in a space filled with dust, and upon smoked plates of glass.*

The means that I have employed appears to me more conclusive still than the action of electric discharges upon photographic plates employed by Mr. Trouvelot. The absolute mobility of the particles of lamp black has permitted me to follow the lines of electric force during the discharges, and I have thus been enabled to show that the discharge produces two vortical motions, *dextrorsum* and *sinistrorsum*, which in uniting destroy every manifestation of the energy derived from the discharge. When we smoke plates of glass covered in the center with a circular piece of tinfoil, and the positive ball of the exciter is discharged against the disk, the lines of electric force delineate, in white upon a black ground, all the aspects of the solar protuberances, in the form of tongues, of flames, and of recurved columns, and often in the form of a spiral.

The image thus obtained is, so to speak, the representation of a total eclipse of the sun, the tinfoil disk representing the moon covering the sun, surrounded at the edges by protuberances projected into space.

If we replace the tinfoil disk by a thick disk of copper, the lines of force derived from the edge most distant from the surface of lamp black become more or less inclined toward the said surface, and the result is a diffused whitish zone perfectly recalling, by its form and texture, the solar corona, and even with protuberances which are projected upon it.

Upon smoking a hollow glass sphere and directing the positive discharges upon the blackened surface, we obtain a representation of the solar spots in white upon a black ground. We reproduce the vortical motions and we recognize the grains of rice, the tongues and the spirals, as we observe them in the penumbra, etc., and the bridges that we see in the shadow of the large cyclonic spots of the sun.

If instead of a smoked plate of glass we take a mirror whose layer of silver is protected by varnish, the discharges not only delineate spots, but through lateral discharges we obtain groups of spots, sometimes large, sometimes small, succeeding each other as they appear in reality upon the surface of the sun in times of great explosive activity. It is, so to speak, the *ensemble* of the solar phenomena produced artificially upon thin unfixed layers of lampblack or silver by the powerful electric discharges of a Wimshurst electric machine or by the Ruhmkorff coil. In a note upon the periodicity of comets (*Comptes rendus*, March, 1883) I have said:

"We can explain the formation of comets by enormous explosions driving the substance of the protuberances to hundreds of thousands of kilometers from the surface of the sun.

"The shocks must propagate themselves to the edge of the corona and drive the matter, which is perhaps meteoric, in advance of it from the corona.

"Let us suppose, moreover, that pretty big meteorites are moving around the sun near the edge of the corona. Their attraction may be greater than that of the sun, and there may be thus produced an agglomeration of coronal matter around the meteoric nucleus, and the head of the comet may be formed; but the attraction of the motion of the mass thus agglomerated may carry along meteoric dust and minute particles of the coronal substance, or what produces the coma and the tail. The resistance of the perpetual shocks of the nucleus against the meteorological matter which abounds in the vicinity of the sun causes the length of the tail to increase rapidly and produces the distorted appearance of cometary tails."

The success of my electric experiments has given me the idea of reproducing the same phenomena by electric discharges against a rugose surface, for example, against the smoked surface of Swedish filtering paper. If the discharges are at right angles, we obtain in white the image of the nucleus of the comet surrounded by the hair in varying shades of gray. But if the discharges are made obliquely to the smoked surface of the paper, we obtain a distorted tail. We observe, moreover, a dark or black line often separating the head from the tail and traversing the latter, as in the large comets, at great distances from the brilliant nucleus.

This is a new proof that constitutes to the better making understood of the enigmatic forms of cometary tails, of their rapid growth in the vicinity of the sun, of the repulsions that they undergo, of the rapid changes in luminosity that they experience, of the flashes that were perceived in the tail of the comet of 1881, and, finally, of a multitude of other phenomena that are wholly inexplicable by universal attraction solely.—*La Lumiere Electrique.*

* Comptes rendus du congres international de meteorologie, Paris, 1878.

† La Meteorologie du soleil et son systeme planetaire, Vienne, 1885.

‡ Comptes rendus, Jan. 27, 1890.

§ Comptes rendus, Sept. 2, 1889.

‖ Comptes rendus, Nov. 3, 1890.

¶ Comptes rendus, Aug. 27, 1883.

* *La Lumiere Electrique*, Nov. 8, 1890.

THE FLORIDA PHOSPHATE DEPOSITS.

By N. H. DARTON.

DURING the past year the phosphate deposits of Florida have become of considerable commercial importance and attracted widespread interest. As practically nothing was on record as to their geologic relations the writer has devoted several weeks to preliminary study of the principal deposits, and this paper is a summary of the results.

The phosphate regions of Forida occur mainly in the western and west central portions of the peninsula, comprising a series of irregular areas scattered at varying intervals along a narrow belt extending from near Tallahassee toward Gainesville, and thence nearly to Charlotte Harbor, a distance of 250 miles. The entire region is not yet fully explored, but the vast extent and commercial importance of the deposits are satisfactorily established, and it is safe to predict that Florida will finally become a prominent source of phosphate. The deposits are exceedingly irregular in extent and richness, and while there are many areas underlain by large bodies of high grade mineral, the great number of the deposits consists of impure, thin or scattered beds of no economic value.

The phosphates are readily separable into three classes: 1. *Rock phosphate*, a homogeneous, more or less complete lithified, light colored phosphate of lime, constituting the surface of the middle Tertiary limestone formation. 2. *Conglomerate*, consisting of pebbles of phosphate rock embedded more or less thickly in a matrix of phosphate sand, marl and arenaceous and argillaceous materials. This fragmental formation lies in great sheets on the surface of the limestone, in some cases overlapping the edge of the rock phosphates, from which its pebbles were derived. 3. *River drift*, consisting of phosphate pebbles derived both from the *rock phosphate* and the *conglomerate*, and constituting great placer deposits in the stream beds draining the other phosphate regions.

So far as is known, the occurrence of the *rock phosphate* is restricted to a narrow irregular belt extending through eastern Citrus County, northward through western Marion, probably to the exposures near Albion, and thence with more or less continuity through Trenton in Alachua, Steinhatchee in Lafayette and Lauraville in Sewanee, possibly to Monticello in Jefferson, Perry in Taylor, and some other reported localities in the same direction. This region is not by any means underlain by a continuous sheet of phosphate, but includes irregular masses of variable sizes and thickness scattered about in detached bodies often widely separated by barren limestone areas.

At Dunellon, in western Marion County, there are representative exposures in the extensive mine openings that are now being worked. Here the phosphate was found outcropping at a number of points in the woods and in low bluffs and reefs in the Withlacoochee River near by. The deposit appears to constitute a large basin, of which the bottom was not reached in a thirty-foot pit in the center. The phosphate is in large part a mixture of chalky and flinty rock similar in texture and structure to spongy limonite, but usually creamy white, gray or bluish gray in color. Some portions consist of dense homogeneous lithified materials, others are spongy, stalactitic or laminated. A fair average sample of high grade mineral was found to contain 88 per cent. of phosphate of lime and 4½ per cent. of carbonate of lime.

The *conglomerate* phosphates occupy a very considerable area in Florida, and although not as rich in phosphate of lime as the phosphate rock, they will be of commercial importance. The principal deposits now known are south of the southern termination of the rock phosphate belt, in the western part of Polk County, in the vicinities of Bartow and Fort Meade, where they constitute sheets of wide area overlying the limestone, sometimes a thickness of from twenty to thirty feet. These conglomerate phosphates consist of small pebbles of 80 to 85 per cent. phosphate rock, usually light colored, embedded in a soft chalky matrix of phosphate sand, carbonate of lime, clay and sand, in variable proportions. High grade conglomerate will average from 73 to 78 per cent. of phosphate of lime.

At intervals along the eastern border of the rock phosphate region and overlapping it at some points there are fragmental and conglomerate deposits of considerable extent, but they are much more diverse in composition than the great sheets in Polk County. At the Dunellon mine, northern opening, there is a deposit of this class and the porous, pebbly sand rock, "chimney rock" of the Gainesville region, appears to belong to the same formation.

The *river drift* deposits of phosphates are of great economic importance, for they are rich in phosphate and can be mined at small expense. Nearly every little water course in the phosphate regions contains accumulations of phosphate pebbles, and along the larger streams there are many thick and extensive pebble deposits. Peace Creek drains the Bartow-Fort Meade conglomorate region and flows over many great placer deposits, some of which are now extensively worked in De Soto County. The Withlacoochee, near Dunellon, and Alafia Creek, northeast of Bartow, also contain extensive accumulations of pebbles. These deposits consist of rock phosphate pebbles usually from an inch to one-quarter inch in diameter, mixed with more or less sand, and usually with bone fragments and occasional flint pebbles from the limestones.

Age and geologic history.—The three geologic formations to which the phosphates belong are distinctly separate stratigraphically, and represent a long interval of geologic time. The rock phosphates appear to be the deeply eroded remnants of the phosphatized surface of the middle Tertiary limestone; the conglomerate deposits overlie these limestones uncomformably and, in the Gainesville region at least, appear to be Miocene in age, and the river drift deposits are apparently entirely subsequent to the great mantle of Pleistocene white and gray sands which covers the entire peninsula to a greater or less depth.

Excepting in its light color the rock phosphate is a physical counterpart of the brown limonite iron ores of the Appalachian limestone valleys, and the deposits have very similar structural relations. I have found at a number of localities that the massive phosphate graduates into the limestone usually by short transitions, and many areas were discovered in the phosphate belt and under the conglomerate in the Bartow region where the limestone is only partially phosphatized. In the mines at Dunellon the massive phosphate is apparently continuous with the limestones, but unfortunately at the time of my visit there were no continuous exposures from rich phosphate to the walls of the basin, and the bottom was not yet reached. So I was unable to establish a graduating sequence at that locality. There are, however, in the massive phosphate, occasional casts and impressions of the same middle Tertiary mollusca undoubtedly lying as they were originally deposited.

The origin of the phosphate of lime is not definitely known, but it seems exceedingly probable that guano was the original source and the genesis of the deposits similar to that of the phosphates on some of the West Indies. Two processes of deposition have taken place, one the more or less complete replacement of the carbonate of lime by phosphate of lime, and the other a general stalactitic coating on the massive phosphates, its cavities, etc.

The apparent restriction of the rock phosphate deposits to the western "ridge" of Florida may have some special bearing on their genesis, but at present no definite relationship is perceived. The aggregate amount of phosphate rock distributed in fragmentary condition in the various subsequent formations is very great, greater by far than the amount remaining in its original position, and it is possible that the area at one time included the greater part, if not all, of the higher portions of the peninsula. As this region apparently constituted a long, narrow peninsula or archipelago, during early Miocene times, it is a reasonable tentative hypothesis that during this period guanos were deposited from which was derived the material for the

phosphatization of the limestone, either at the same time or soon after.

The pebbles of the conglomerate phosphate were undoubtedly derived from the rock phosphates, for they are identical in appearance and composition and overlap them as a shore deposit. Evidence in regard to the age of the conglomerate formation is very meager. The only organic remains I met with were two imperfect casts of Pectens in the "chimney rock" near Gainesville. These had a Miocene aspect, but the evidence is not by any means conclusive. This "chimney rock" of Gainesville is a porous sandstone containing a small proportion of pebbles of phosphate rock, lying uncomformably above the Vicksburg limestone. It is the structural equivalent of the conglomerate beds of the Polk County region, but they may prove not to be identical in age.

The phosphate deposits of Florida will require careful detailed geologic exploration before their relations and history will be fully understood, and it is the purpose of these preliminary notes only to throw some light on their more general features.—*Amer. Jour. Science.*

THE CRYOLITE MINE OF GREENLAND.

THE deposit of cryolite at Ivigtut is unique. There is no other mine or quarry like it in the world. Very small quantities of cryolite have been found at Miask, in the Ural Mountains, and a trace was found at Pike's Peak, in the United States. A man who reported the Pike's Peak deposit to an interested capitalist in the East was offered $150 for a ton of it, but the delivery could not be made. As a workable deposit the Ivigtut pocket stands alone. A good deposit of cryolite anywhere within reach is worth as much as a gold mine. Pure cryolite, to the ordinary observer, is a white stone. It is a good deal like white quartz and a good deal like ice that has a mixture of snow in it. Eskimos call cryolite the ice-that-never-melts, while the name cryolite is from Greek words meaning ice-stone. If any one should happen to find a deposit of white rock anywhere and imagine that it was cryolite, a piece of the rock should be soaked in clean water. If it then has the appearance of wet, opaque ice, the next thing to do is to try to cut it with a knife. If it cannot be cut, it is probably quartz. If it can be shaved down into a powder very easily it may be cryolite, and samples should be sent to an expert.

But not all cryolite is white. Some of it is light brown and some very dark. This is usually due to vegetable matter that has soaked into it, or it may be due to iron. If a piece of the dark stuff be heated very hot—say by putting it on top of a hot stove—it will whiten, the vegetable matter being driven off. Another way to determine the character of a supposed piece of cryolite is to analyze it.

If the rock be fluoride of sodium and aluminum, it is cryolite. That is, it consists of three chemical equivalents of sodium, two of aluminum, and six of fluorine. It has a hardness of 2·5, a specific gravity of 3, and it cleaves in three directions.

In 1806, a German named Giesecke, thinking that valuable minerals might be found in Greenland, applied to the Danish government for permission to go there and prospect the mountains. He searched the coast from Cape Farewell up, living with the Danish governors or the Eskimos, as circumstances dictated, until he reached Arsuk Fiord.

Here he fell in with an intelligent Eskimo who had been taken to Denmark, educated, placed in government employ, and finally discharged and sent back to Greenland for disrespect to his superiors. That man told Giesecke about a deposit of ice that never melted on the edge of Arsuk Fiord. It was powdered and used by the natives in tanning skins. It acted on a greasy hide as soap would act.

Giesecke went to see the deposit. It cropped out on the south side of the fiord at the water's edge. The prospector gathered abundant samples, for it was an entirely new substance. The next year, with his new-found rock and a lot of other specimens from Greenland mountains, he sailed for home. Unfortunately for him, Denmark was then opposed to England in the war that was stirring up the world, and the Danish ship was captured by a British man-of-war, carried to London, and sold as a good prize.

The cryolite went to a British institution, where it was analyzed and its constituents were determined. It received a name which, for many years, students of chemistry committed to memory, and then forgot because it was not of any other value in the world than as a curious compound of certain elements.

Then a distinguished chemist named Thomsen discovered that a substance very useful to mankind—sal soda, also bicarbonate of soda—could be made cheaply from cryolite, and not only were these substances cheap, but they were free from all impurities. That discovery led to attempts to work the deposit. As early as 1852 a little work was done in the quarry, but regular work was not begun until 1860. No money was made out of the quarry until 1864. Indeed, although steadily worked since 1860, previous to the year 1864 some hundreds of thousands of dollars were sunk in attempts to develop the cryolite industry.

Until 1864 the entire product of the mine went to Europe. Then an American firm, the Pennsylvania Salt Manufacturing Company, of Natrona and Philadelphia, Pa., of which Mr. Theo. Armstrong is president, began to import it. This company was originally organized to make soda ash from the salt obtained from salt water wells at Natrona, twenty-four miles from Pittsburg. It is said that owing to competition with other concerns which had more cheaply worked deposits of salt, the profits had been reduced to an unsatisfactory limit, when at about the date mentioned the scientific directors of the company began to consider the advisability of importing cryolite. One of their directors thereupon was sent to Denmark, where he had abundant opportunity to examine and test the kryolith, as it is there called. The tests proved so satisfactory that a contract was made by which the Pennsylvania company was to have some thousands of tons per annum, and in any event two-thirds of all the product of the mine. The contract was for twenty years, with the option of extension. The option was taken at the end of the first period.

The difficulty was to get the cryolite from Ivigtut to Natrona. When a representative of the company called on a Philadelphia ship broker to see about chartering vessels for the purpose, the broker thought some of his fun-loving associates had sent the man to him as a joke. When convinced that vessels were really wanted to go to Greenland, he advised the company to apply to a St. John's (N. F.) whaling shipowner, and for a year or two whalers, chiefly from Scotland, were employed.

Capt. Adam Smith made his first voyage to Ivigtut on one of these vessels. He has completed thirty-two voyages to the Greenland seas. In 1866 several American and Nova Scotian vessels were chartered for the trade, but after a few years' trial the American vessels abandoned the trade, and it was again transferred to the Danish and Scotch ships. The trade had many reverses, as the vessels were old, and neither the Danish nor Scotch shipowners were disposed to infuse new blood into it in the way of building suitable vessels for such navigation.

In 1876, Capt. C. B. Dix became the partner of Capt. L. McKay. Having had considerable experience in the Greenland trade, they were desirous of trying their fortunes again in that icy land. They knew what kind of vessels were needed. They accordingly proposed to the Pennsylvania Salt Manufacturing Company to build as fast as possible suitable vessels that would carry all the cryolite obtainable. Their proposition being accepted, the barks Ivigtut and Natrona, the first of the present fleet, were constructed. Every care was bestowed in the building and equipping of the vessels, also in the selection of suitable captains to command them.

Capt. Adam Smith, now of the Argenta, was one of the first employed. During thirteen years' experience McKay & Dix have built twelve vessels, all of which, except the two previously mentioned, have chemical names, viz., Kryolith, Alumina, Fluorine, Silica, Iodine, Sodium, Salina, Silicon, Platina, and Argenta; hence they are called the chemical fleet.

Under the management of this firm the annual importations are from 8,000 to 10,000 tons. The first cargoes were delivered at Quebec and taken through by river and lake to Cleveland, Ohio, and thence by rail to the works at Natrona. That roundabout course was soon abandoned, however, for the direct voyage to Philadelphia, and thence by rail to Natrona. Frequently the ships are nipped in the ice off the Greenland coast, and are so badly damaged that they must return home for repairs.

THE MINE.

When work was first begun on the deposit it cropped out as a wide seam a few feet from the water of the fiord at high tide. An exploration showed, however, that the deposit was a pocket rather than a vein. The lay of the south shore is east and west. From the water's edge the deposit plunged down to the southward under the mountain at an angle of about 45 degrees. The rock above, in fact all around it, is granite. When the deposit had been uncovered, it was found to be more than 400 feet long by nearly 200 feet wide. To this day the owners do not know how deep it is, but they have dug it out to a depth of 100 feet and have drilled 140 feet farther, and found cryolite all the way. At the surface the cryolite was as pure and white as the snow. Huge blocks without speck or spot of impurity were blasted out and placed on board the ships. As they worked down, the miners found crystals of iron ore. The chunks of cryolite thus defiled were promptly dumped into the fiord along with the covering rock. The iron ore is a perfectly pure carbonate of iron, and could be used in the Bessemer process of making steel if in sufficient quantities. In addition to the carbonate of iron were sulphurets of iron and copper, beautiful specimens of lead ore, and several other interesting minerals that are found only in connection with cryolite and, until recently, entirely unknown. Among these are pachnolite, thomsenolite (named after Prof. J. Thomsen, who originated the cryolite industry), arksudite, geoarksudite, and hagemanite, which was named by Prof. Silliman after Mr. Gustav A. Hageman, the assistant chemist of the Pennsylvania Salt Manufacturing Company, who first analyzed it. But these impurities are readily separated from the cryolite in the process of manufacture, as they suffer no change under the chemical treatment by which the cryolite is decomposed.

The deposit, as a whole, may be readily pictured if the reader ever looked at a mountain spring where the water, boiling up through a hole in the bottom, kept lifting the sand there and holding it in suspension so that the water was discolored at the bottom but pure and limpid at the top. When this deposit of cryolite was found, it boiled up in liquid form from a hole below, bringing with it iron and lead as the water in the spring brings sand. Then it solidified. Because the iron and lead were of greater specific gravity, they remained near the bottom. Such is the cryolite deposit of Ivigtut.

The mine is only a hole in the ground, elliptic in shape, and, say, 450 feet long by 150 wide. It lies parallel with the water. The wall of the hole on the water side is about vertical, while on the south side it is vertical also, except that wide pockets between huge pillars have been dug in under the overlying granite to follow the lead of the cryolite. The overlying rock on that side is about forty feet thick. On the water side is an inclined railway, where loaded cars are hauled up as empty ones come down, just as is done in coal mines. A pump shaft on this side extends twenty-eight feet down from the bottom of the mine, and all water drains into that. The pumps and engines are good, but not novel. While we were there one gang of men was blasting up the bottom of the quarry and another was at work cutting down a terrace at the western end. The drilling of the holes for blasting was by hand. The blasts are discharged while the men are away at meals. The pieces of mixed ore and cryolite are placed on blocks of wood, and are broken apart by hand, the cryolite going into one pile and the other ores into another. The refuse has been used for constructing the wharf.

In summer the men work at the bottom of the hole. In winter they work on a novel staging that is readily made there. The water of the fiord is let into the mine, and when it has frozen over, the men work on it to clear off surface rock and to cut down benches or terraces for the next season's work.

At the end of April, when the Fox, with a complement of men for the summer, is expected, the mine is pumped out and the ice is broken up and hauled away. It takes twenty days and nights to pump out the mine.

ON THE WHARF.

The wharf is about 500 feet long and 100 wide. It is simply a dump heap of refuse from the mine, but it has been floored over with heavy plank and supplied at the water side with substantial spiles and bedded anchors for mooring the ships. Three ships can load at once. They are moored about thirty-five feet from the edge, with which they are connected by heavy gang planks.

The name of the Danish company working the mine is the Kryolite Mining and Trading Company. It pays a royalty of one-fifth to the Danish government. The most careful account is, therefore, kept of every ton mined.

From the mine the cars are run by hand to the wharf, where small pieces of iron ore bolted on the floor locate the corners of the piles which must be built. The piles are of various sizes, but they average about 25 by 100 ft. and 4½ ft. high. The men who make the piles use as much care as they would if building cellar walls for country houses. Lines are stretched between the iron-marked corners and then walls of big blocks of cryolite are built to those lines, the blocks being squared by the use of the hammer, so that the wall is solid. As the wall is built up, the space within is filled Only pure white or No. 1 cryolite is used in building the wall, and when the pile is of the required height, lumps of pure white cryolite are thrown on top, and broken up until the top is covered and slightly rounded.

These piles are carefully measured, the unit of measure being a cubic fathom. It is Controller Muller's duty to keep the record of these piles and the shipments. A representative of the Kryolite Company records the weighing at Philadelphia.

LOADING CRYOLITE.

The Argenta was moored at the wharf on Thursday, September 25. By noon next day she had the first wheelbarrow load of cryolite on board. But the cryolite, being about as heavy as limestone, cannot be dumped down in the bottom of a ship and left there. The Argenta had a platform built across and fore and aft about four feet above her floor to raise the center of gravity of the load. If the center of gravity of a load is too low in a ship she will roll violently, and endanger at least her spars, and not unfrequently the hull.

On Saturday afternoon the Fluorine, Capt. Johnsen, arrived from Philadelphia. The Sodium, Capt. Anderson, arrived on Sunday afternoon, and thereafter the port of Ivigtut presented a scene of animation. With the aid of the Fox's crew and some shore help we got 410 tons of cryolite on board by Tuesday night, the end of the fifth day, and on Wednesday morning hauled the ship out until she was in ten fathoms of water, where the ballast was dumped overboard. Then she was hauled back, and the loading went on as before.

That only ships built in the strongest manner possible could stand this trade is shown by the fact that the Silicon, another of the fleet here in July, was obliged to go home in ballast, having been on a rock near the mouth of the fiord, and started a leak. The Sodium came into port leaking several inches of water an hour. She took on less than a full load, and was ready to sail when we sailed; but her captain had a strong presentiment of evil to come, and he remained in Kajartolik harbor at the mouth of the fiord when the Argenta and the Fluorine sailed. She has since delivered her cargo at Rhita.

USES OF CRYOLITE.

By certain processes cryolite, the fluoride of sodium and aluminum, is converted into sal soda or carbonate of soda, into bicarbonate of soda, into alum, and into caustic soda. To chemists the processes are said to be extremely interesting because they are simple and because the products are absolutely pure, the alum from cryolite being unique in this respect. Cryolite has also been used in the manufacture of opaque glass. Mixed with sand and oxide of zinc, a glass that very closely resembles porcelain and is yet almost as tough as iron is produced. A company has been organized to produce the metal aluminum from cryolite. Experiments have been so successful that a large factory is in operation in Pittsburg, and several are contemplated in other cities for turning out that wonderful metal at a price less than $1 a pound. The product is on the market, and in two or three years will probably sell for less than 50 cents a pound.

The importing and handling of cryolite and its products give employment to nearly 2,000 men, who earn close to a million dollars a year. Several millions of capital are employed, and few enterprises have been supported so lavishly as the Pennsylvania Salt Manufacturing Company has been supported in the development of the cryolite industry. It required a deal of money, as well as skill and patience.

THE CLIMATE.

Ivigtut is in latitude 61° 12′ north. It is about the latitude of the palace of the Czar of Russia in St. Petersburg. It is not so far north as localities where very many Swedes and Norwegians live, not to mention the other whites of northern Europe. When we were in Ivigtut it was light enough to work about decks at 6 o'clock in the morning, and the last barrow of cryolite was dumped into the Argenta's hold at 7 o'clock at night. We arrived with the first snow of the season. It was a light snow, that melted as it struck the deck, but it whitened the upper part of the mountains, say down to within 500 feet of the water. This snow remained and was increased by two or three other snow storms, but the Danes said that it would surely leave even the mountain tops on the arrival of the first southeaster, and that southeasters, with their warm rains, always cleared the snow from the mountains until along in December. There was no snow on the ground at the water's edge when we sailed away, but there was some three or four hundred feet up. All the fresh water ponds and lakes were frozen over by a cold snap before we left to a depth of perhaps three inches at the most. The air by day, except on the rainy days, is best described by the word bracing, but on even the warmest days when the sun had gone behind the westerly mountains the air became piercing cold. But the feeling was much colder than the thermometer indicated. With the Fahrenheit thermometer at from 15 to 20 degrees everybody about the ship who had them

wore three flannel shirts. With less clothing on I have been more comfortable in the Adirondacks when the same thermometer was 15 or 20 degrees below zero.

The fiord, which at Ivigtut is 2½ miles wide, is usually frozen over early in November, but last winter it was not frozen. The ice is usually out of the fiord by May 1, but near the upper end of the fiord the water is very nearly fresh, owing to the stream that flows out from under the glaciers there. Willows are always in full leaf the first week in June.

When Dr. A. Hagerup was physician at Ivigtut, he kept a meteorological record. He found, according to data left behind, an average temperature of a little lower than 5° Centigrade during the three coldest months of the year, while from the middle of June to the middle of September the average was about 7° Centigrade. During one winter (1886–87) the lowest degree reached was 28, and the highest during the next summer, 21. The last year he was there a total of 35½ inches of rainfall was noted, but that is said to have been a rather dry year. The past summer there was more rain than during any season for several years. Very few bright days, not over a dozen which were bright all day, were noted until the frosts of September came.

It is said that at Julianshaab, near Cape Farewell, is a family that has owned a herd of cattle for more than 100 years, and that both butter and cheese of an exceptionally fine quality are produced. The cattle are small in size, but apparently healthy. They have diminished in size during the recollection of living people, and this diminution is said to be due to the climate. Abundant hay is raised for their keeping. The fiord and the ponds produce mosquitoes with appetites of the most vigorous nature.

One of the features of Ivigtut likely to attract the attention of the stranger is the truck raising. Three or four gardens have been formed by clearing away the rocks, the largest being about 30 × 50 feet in size. With the aid of window sashes very fine crops of Scotch kale are matured.

THE MYSTERY OF THE FIELD ICE.

Local causes, rather than the latitude, make south Greenland unfit for agriculture. Along the shores of the Arsuk fiord there is very little soil to cultivate except in one or two valleys like the one just above Ivigtut. The soil is black and rich, but the obstacle in the way of cultivating that soil successfully is the current that brings field ice from the east coast of the country down around Cape Farewell and up along the west coast. The movements of this ice are mysterious. In general it is known that the field ice goes with the current, or, when the wind is the stronger, with the wind.

But that does not account for all the movements. A current like a wide river sweeps up the coast with a pack of ice a hundred miles long on its bosom. As it passes the fiord on a calm day the ice, or large quantities of it, will suddenly take a set into the fiord. Thus at 9 o'clock it has been noticed that not a cake of ice was in sight at Ivigtut. At noon the fiord was full of ice. At 4 o'clock not a cake was in sight. On other days, apparently precisely like that day, a single cake may float off Ivigtut all day long, and perhaps stay there three days. On other days of like character no ice is seen, although there may be plenty of it off the mouth of the fiord. The tide very likely has something to do with the movement of the ice, but the ice sometimes comes in against the ebb tide and goes out against the flood. The reader who has looked at deep pools below a waterfall has undoubtedly seen bodies of the water boil up as if from a spring in the pool; not a violent ebullition, but a gradual rising of a large volume of water to the surface. This rising of the water would scatter floating debris in all directions. There is something about the movements of ice off the coast of Greenland to suggest just such upheavals of water from the depths below.

Of the meteorological phenomena of this part of Greenland, nothing probably is more interesting than the easterly gales that rage along the coast. Because of the extraordinary force with which the wind courses down the mountain sides and out of the gorges and valleys, the utmost care has to be taken in mooring the ships. Indeed, a ship was once known to break a good chain cable by which she was moored at the bow and go drifting off with the gale. But not only is the gale interesting because of its extraordinary power, it is peculiar in its phases as it rises. One night the overcast sky began to clear in the east and then to whiten as if the moon were rising. A little later the cabin door opened without apparent cause, and a chilliness, followed by a warm breath, pervaded the room. The captain shook his head, but said nothing, although he thought, as he said afterward, that the door had opened for an unwelcome guest. Half an hour passed before the guest appeared again, and then its presence was manifested simply by a sigh in the rigging. A full hour passed, and then it came again, a gentle breeze that sighed through the rigging, a breeze that made the wires sing, a squall that whizzed around us, and then the gale, roaring and screaming upon us and across the fiord, rolling the cryolite across the deck, tearing the planks from the staging, and beating against the ship until she groaned and trembled. But the captain said it was only half of what is sometimes felt.

But when we lay in Kajartalik harbor waiting for the ice to clear away from the mouth of the fiord, that we might sail for home, we saw the gale in all its glory. It was on Sunday, October 12. The lofty peaks of Kungnat were behind us, and away across the fiord towered those of Storo and Saverut. Snow had fallen during the night, but early in the morning the sun came out bright and clear, while the gale intensified until its power was terrific. Leaping from crest to crest and bounding from side to side of Kungnat, the wind whirled in tornadoes down upon the water, tearing it into spinning columns of spray. Unchecked, the gale left the water and swept up the valleys and the gorges and the precipitous sides of the mountains, gathering the loose, dry snow in its embrace as it went, carrying it up and up to the very crests, and there hurling it away in spouting streams and fleecy clouds, that spurted and soared more than a thousand feet above the loftiest peaks, more than four thousand feet above the level of the sea, to fade and vanish slowly out of sight.

Woe betide the ship caught in the open fiord by one of these gales. There is no escaping its fury without serious damage, while fatal results are avoided only by extreme vigilance and a prompt squaring of the yards, that she may be driven out to sea. Capt. Smith, of the Argenta, was once driven out of the fiord, and he was able to bring his vessel to her course four degrees of latitude away.

The perils and discomforts of the voyage, balanced against the pleasures, may be endured willingly, and among the latter not the least is the pleasure of looking at the effects of an easterly gale from a safe harbor near the mouth of the fiord. Another great pleasure is in the spectacle afforded nightly by the aurora borealis. If there be any manifestation of the powers of nature that will convey a conception of the dawn of the day which shall come like a thief in the night, in which the heavens shall pass away and the earth and the works that are therein shall be burned up, that manifestation will be found in the electrical flames that cover the skies of Greenland at night.—*N. Y. Sun.*

LOMARIAS.

THE species and varieties belonging to the genus Lomaria have a wide geographical range, and are met with in various parts of South America and South Africa, in the Mauritius and in Australasia, whence some of the finest kinds in cultivation have been introduced. With such a wide distribution they, as

LOMARIA PROCERA DUTTONI.

might be expected, differ materially in character, but they are all of comparatively small growth, and with but one or two exceptions they can be most successfully cultivated in a cool or intermediate house. Some have so robust a constitution as to be admirably adapted for the decoration of indoor apartments, in which, with ordinary care, they can be maintained in excellent condition for a considerable period. They are not suitable for the supply of fronds for association with cut flowers, but for arranging in baskets or groups, or for placing singly in vases or other ornamental receptacles, they are exceedingly useful.

They will, with but few exceptions, grow vigorously in the stove, but the majority will thrive in the cool fernery or intermediate house, and they are, therefore, specially adapted to the requirements of those who are unable to grow ferns and other plants for which a high temperature is necessary throughout the year. They all agree in requiring rather liberal supplies of water at the roots, but they differ somewhat in their requirements in the matter of soil. Speaking generally, the small growing species and their varieties should be potted in good fibrous peat to which a liberal addition of sand has been made; while the strong growers should have a mixture consisting of turfy loam and peat in equal parts, and silver sand in the proportion of one part to seven or eight of the mixture. The majority of the kinds can be readily increased by means of the spores, and for those grown for indoor decorations a few plants should be raised annually or every second year to insure a continuous supply of healthy examples of a suitable size. Such kinds as L. ciliata and L. gibba are extremely beautiful when they are grown to a comparatively large size, and have stems ranging from one to two feet in height. In the course of the summer of the past year we saw the last named of the two species employed with singular success in the embellishment of the drawing room. Large tables, having marble tops, were placed in suitable positions, and wholly filled with ferns. In arranging them a groundwork was formed with rather small examples of various adiantums, and at intervals were placed specimens of L. gibba, having stems about fifteen inches in height, and surmounted by well developed fronds. The latter were just far enough apart to prevent the fronds touching, and the general effect was exceedingly tasteful. Some of the species may be grown on the dead stems of dicksonias, alsophilas, and other of the arborescent ferns with considerable success. Stems of medium size and ranging from twenty-four to thirty inches are the most suitable, and it is simply necessary to fix them securely on the top of the stems, and to supply liberally with water. In a short time after they are placed in position the roots begin to run down the sides of the stems, and are not long in reaching the pots in which the stems are fixed. It is therefore necessary to use a suitable compost for placing about the stems, and also to keep the latter moderately moist. The most suitable species for growing in this way are L. ciliata, L. gibba, and L. nuda.

The several species differ materially in their adaptability to the requirements of the general body of cultivators, and it is therefore a matter of some importance to exercise considerable care in making a selection. The following comprise the best for collections of ferns of limited extent, and should in all cases have the preference:

L. blechnoides.—An elegant Chilian species, the fronds pinnatifid, about ten inches in length, coriaceous, and of a dark green hue. It presents a charming appearance grown in pots, and is well suited for planting on the rockwork of a cool fernery.

L. ciliata.—A handsome and useful species introduced from New Caledonia, and thriving in the intermediate house. The fronds are pinnate, occasionally pinnatifid, blunt at the points, and having along the margins hair-like teeth. It has a distinctly arborescent habit, and the specimens present the most attractive appearance when having stems ranging from nine to twelve inches in height.

L. cycadoides.—A distinct Brazilian species of noble aspect, the stem short and stout, furnished with brown scales, the fronds about twenty-four inches in length, pinnate and of a dark green color. May be grown either in the greenhouse or intermediate house.

L. discolor.—A beautiful species, native of New Zealand; the fronds are pinnatifid, about eighteen inches in length, dark green above and light green on the under surface; the fertile fronds are much contracted, the pinnæ being linear. The variety known as *L.*

discolor bipinnatifida has fronds rather larger and more finely cut than are those of the type, and is extremely elegant in appearance.

L. fluviatilis.—An elegant species introduced from New Zealand, the fronds about eighteen inches in length, rather narrow, the pinnæ roundish and alternate, which, with the rachis, are covered with reddish hairs.

L. gibba.—A distinct and handsome species, which has proved to be the most useful of all the lomarias for

ERECT FROND OF LOMARIA PROCERA DUTTONI.

general decorations, and is appreciated accordingly. The fronds attain in a fully developed specimen a length of two feet, and are pinnatifid and of a light green color. In a small state this species is useful for the decoration of the drawing room or dinner table, but the plants present the most attractive appearance when sufficiently developed to have a stem rising from one to two feet in height. *L. gibba crispa* is distinguished by its dense fronds and crisped pinnæ, and *L. gibba tincta* is remarkable for the reddish hue of the young fronds.

L. L'Herminieri.—A distinct species of comparatively small growth and requiring a place in the stove or intermediate house. The fronds are pinnatifid, about eight inches in length and six inches in width, red-crimson when young, changing to a dark green hue with age.

L. magellanica.—A handsome species of bold growth and a native of Chili, Juan Fernandez, and the Falk-

DROOPING FROND OF LOMARIA PROCERA DUTTONI.

land Islands. It has a short, moderately stout stem, and fronds about eighteen inches in length and of a dark green color.

L. nuda.—An elegant Tasmanian species, the fronds pinnatifid and light in appearance. It is well suited for the dinner table, and is quite at home in the greenhouse.

L. Patersoni.—A distinct Australian species, with simple narrow dark green fronds. *L. Patersoni elongata* has large pinnatifid fronds, which are coriaceous in texture and of a dark green hue. Both are useful for their distinctness.

L. procera.—A handsome species distributed over the greater part of Australia, Tasmania, and New Zealand. The fronds are pinnate, range from twelve to twenty-four inches in length, and from five to seven inches in breadth, according to the vigor of the plants.

The pinnæ of the fertile fronds are much contracted and present an elegant appearance. At Kew the species is grown in the tropical and cool ferneries and in the temperate house, and the condition of the examples in the several structures clearly indicates that a temperature equivalent to that of the greenhouse is the most suitable.

L. procera Duttoni is an extremely elegant variety, found by Mr. John Dutton, Springfield Road, Christ Church, New Zealand. The chief points of difference as compared with the type are the more leafy character of the outer fronds, the long whip-like pinnæ of the central fronds, and the absence of sporangia. The latter is an interesting point, for the central fronds present much the same appearance as do the fertile fronds of the type, but are wholly sterile. Mr. Dutton informs us that he has had the variety in his collection twelve years, during which period it has proved quite constant. The central fronds rise to a height of two feet, the pinnæ are four inches in length, linear, distinctly serrate, and much curled, as shown in the figure of the erect frond.—*The Gardeners' Magazine.*

WITCH-HAZELS.

THERE are so few winter flowering trees and shrubs that any blooming in the dull season should receive careful attention. Among the number are the Hamamelæ or Witch-Hazels, which expand their flowers in the depth of winter, and form excellent companions to Chimonanthus fragrans, Jasminum nudiflorum, Lonicera fragrans, and L. Standishi. There are several

TREE WITCH-HAZEL (*Hamamelis arborea*).

(Flowers crimson and yellow.)

kinds in cultivation, and one of the most generally known is, perhaps, Hamamelis Virginica, a distinct species introduced in 1737. It is interesting rather than attractive, the flowers being insignificant and dull in color. The kernels are edible and the leaves and bark are astringent, and also contain an acrid essential oil. H. japonica and H. Zuccariniana have attractive flowers, and are of considerable value for associating with other ornamental trees and shrubs.

The finest of the group is unquestionably the tree Witch-Hazel (*Hamamelis arborea*), a distinct species, introduced within a comparatively recent period. It is a native of Japan, and is a most valuable shrub, growing usually to a height of about eight feet, and succeeding well in most soils. A sunny position is required to insure the thorough ripening of the wood, and the consequent production of flowers. The growth is vigorous, but somewhat ungainly, but this is atoned for by the beautiful aspect of the shrub when in full bloom on a sunny January day, the numerous flowers with which the leafless branches are studded being then especially attractive. The flowers are axillary, produced in small clusters, the short sepals deep crimson, and the long linear twisted petals are deep yellow. Under favorable conditions they are produced so profusely that the twigs are completely hidden beneath their floral covering. This Witch-Hazel is thoroughly well worth planting for the sake of its winter effectiveness in the shrubbery border, as so well exemplified by the specimen in one of the groups near the Temperate House at Kew.

The popular name of the genus is derived from the hazel-like appearance of the leaves, which burst out in the spring after the blossoms have faded.—*The Gardeners' Magazine.*

FIRES—HOW TO PREVENT AND HOW TO STOP THEM.

MR. C. J. H. WOODBURY, of the Boston Manufacturers' Mutual Fire Insurance Company, recently delivered a lecture on "Conflagrations in Cities," containing much matter worthy of thoughtful consideration, as well as many interesting particulars not generally known, some of which we here present. The causes of fire are as infinite as the varying conditions of the numberless possessions of mankind; and beyond that, the forces of nature contribute, in no small degree, to the fire loss. Whether it be the overheated baker's oven at London, the balky cow at Chicago, the neglected waste in the engine room at Boston, all great fires result from neglected small ones. Every method of construction, every process of manufacture, every material in commerce, as well as every type of fire apparatus, and the orderly conduct of affairs, bears some relation to the fire hazard. The function of the underwriter is not merely to give to these elements their just weight, but yet more to rise from a consideration of physical conditions to the higher and ethical questions relating to the moral hazard as measured by the probity of owners, who are always possessed of every opportunity to effect the destruction of their property by fire. The facility with which insurance can be effected, and the readiness with which losses are paid, renders incendiarism the great undetected crime of the present day.

The work of the underwriter is largely dependent on that of the architect, because every variety of building material and every method of construction, irrespective of the use to which the building is put, is more or less destructible by fire; therefore, the work of the architect must be judged in a certain measure by the methods of the underwriter. There are certain types of construction of commercial and manufacturing buildings in cities which experience has shown to be peculiarly adapted to resist destruction by fire, and a general consideration will be given to some of these methods. If a building could be so constructed that its contents could burn and destroy the interior, without endangering the neighboring buildings, it could never cause a conflagration. A fire-proof building, however, is a commercial impossibility, because if one be constructed so as to withstand the destruction of its contents, it would be good for little else, and the cost would be prohibitive. When William A. Green was chief of the Boston fire department, he received a letter from an official at Berlin asking for a description of the fire-proof public buildings at Boston. He replied that they had but one, the Beacon Hill reservoir, and sometimes they did not feel quite sure of that.

The first consideration should be given to the means of reducing the conflagration hazard. This is accomplished simply by the maintenance of the walls, the protection of all necessary openings, the abolition of wood cornices and the protection of the roof, all of which precautions have been taken in most of the first-class buildings in cities. Brick division walls, heavy enough to withstand the excessive stresses incident to a fire, will be uninjured by flames which cripple iron and decrepitate stone. It is preferable that all walls should extend above the roofs; but where that cannot be done the cornices should be of terra cotta, stone or metal.

All openings in side or rear walls which would become a source of danger in case the adjacent buildings were on fire should be provided with fire-proof doors or shutters, which should always be closed at night. These doors or shutters should be made of two thicknesses of matched boards, of thoroughly seasoned stock, laid at right angles to each other and covered with sheets of tinned iron laid with locked joints similar to the method generally used in tin roofing. The hangings, whether tracks or hinges, should be secured directly to the wall, and fastened to the door or shutter by carriage bolts, not screws. The butts for outside shutters should be made of galvanized iron, or some other material which would not allow the hinge to stick by rust. In division walls of large buildings these doors should be double, one door at each side of the wall. Doors made after such a method have resisted the most severe exposure in burning buildings; while it is known that either wrought or cast iron doors cannot withstand the heat of any considerable fire.

The floor supports should be attached to the walls in such a way that the walls shall not be injured by falling beams or girders. The preferable means for accomplishing this result is first to place the beams so they will not penetrate too near to the outer face of the wall. They should then be secured to the walls by a wall plate, with a tongue entering a transverse groove across the under side of the beam, or by the cast iron anchorage box. Wood beams anchored to the walls by either of these two methods will not endanger the walls in the event of a beam falling from any cause. In the case of iron girders the problem is different, as the changes in the length of such girders with ordinary variations in temperature would not permit a rigid anchorage. This expansion has been sufficient in case of fire to produce serious results.

The question of roofs is a very important one, both in regard to their yielding from a fire inside and also their ignition from outside exposure. The statement made by Benjamin Franklin, that "next to a good foundation, a good roof is the most important part of a house," is even more applicable to-day, as the crowded condition of cities has given other functions to roofs than merely those of shelter.

The most substantial roofs for commercial buildings are those constructed of plank, and nearly flat, having a slope of half an inch to the foot either toward the center or the edges. When the various courses of roof covering comprise a solid thickness of three inches of wood without any intervening air space, then the building is covered with a roof which will protect the upper story against extremes of temperature—resisting both the heat of summer and the cold of winter. A fire of the contents would not burn through such a roof so long as the supports were intact; and if the outside was protected by any roof coverings suitable for flat roofs, it would be difficult for a neighboring fire to inflict any injury on such a roof. It is important that such a roof should have an opening covered with a door as thick as the roof, and that it should be provided with a permanent ladder or stairway leading to it.

It is not easy to introduce changes in the hazard of dwellings, as their owners are not inclined to vary from customary methods, but the owners of mercantile and manufacturing property are far more ready to give consideration to suggestions designed to reduce the fire risk. A building made of incombustible material is not necessarily fire-resisting, as a combustion of the contents of almost all commercial buildings, except office buildings, will weaken unprotected iron beams and columns, and reduce the strongest stone to powder. This destruction of rock is caused by the conversion into steam of the water absorbed by the stone.

Nearly every city is provided with building regulations, which are generally teeming with errors of omission, and often contain provisions for methods of construction which are as far behind the times as the old buildings which are torn down to make way for the new structures to be erected in accordance with the provisions of the new regulations. The increasing height of buildings, whose profitable use has been made possible by the passenger elevator, presents a problem which is not fully met by the use of incombustible material in construction. Want of care in the construction of flues or chimneys is the cause of an enormous number of fires, especially from cracks caused, in many instances, by girders or beams too near chimneys. Soot deposited in such cracks becomes ignited in the course of time and acts as a fuse to ignite some of the woodwork at the floors or the interior finish of the building. Hollow concealed spaces in floors and walls are a source of great destruction by fire. It is certainly preferable, as regards matters of safety, to design buildings without such dangerous spaces; but the traditions of construction seem to be so entirely opposed to such methods that they must be recognized, and faulty practice modified as far as possible by the introduction of fire stops in all vertical concealed spaces at each story, and any continuous spaces, particularly in the attic, should be cut off at as frequent intervals as can be arranged.

The ceilings over furnaces, boilers and hotel cooking apparatus, if near enough to become in any manner a source of danger, require special provisions to insure safety. All hollow spaces should be removed, and woodwork is generally best protected by means of lime plaster laid on wire lathing, conforming to the surface of the under side of the floor. The supports of the building should be arranged to resist injury as a result of the combustion of the contents or of the lighter portion of the interior. Timber beams and columns fulfill this purpose as well as any material; but it is frequently necessary to use iron or steel to obtain the necessary strength, in which case the metal should be protected with heat-resisting material, generally with special tiles made for the purpose.

The best type of a commercial building is that where the floors are continuous; the openings for elevators, stairs, and transmission of power being an inclosed-in tower. This isolation of the various rooms from each other would render such a building well nigh indestructible by fire, but such a separation would not generally be considered adapted to commercial buildings, with the exception of storehouses. During the last year I designed a six-story building of this description, which is situated in the compact portion of a city, and occupied by numerous tenants engaged in various kinds of manufacturing. The floors of this building are of the usual slow-burning construction type, the timbers consisting of Southern pine beams of 18 feet span, bolted in pairs, making solid beams 12 × 14 inches, and laid 8 feet on centers. The floors upon these beams consist of three-inch spruce plank planed underneath and with splined edges. These planks are 16 feet in length, and therefore each one rests on three beams. In order to render the load on the beams uniform, the courses are broken every two feet. Two thicknesses of asbestos paper are laid on the plank before the top flooring of birch is laid. The roof is similar in construction, but only three inches thick. It is lowest in the middle, and the brick walls form a parapet around the sides. All windows, except those at the front, are provided with tinned shutters. The peculiar feature of the building, however, is the means used to isolate the various stories, from each other by making the floors entirely continuous and without any openings whatsoever. A tower in the middle of the building, placed 24 feet from the entrance, and measuring 10 by 17 feet, made of brick in the lower portion and three-inch plank above, extends through the roof and is covered by a large skylight, protected, as all skylights should be by a wire netting underneath. This tower contains stairways and elevator, and at the rear of it is another division for the wash rooms, and to carry steam and water pipes. Adjoining this is the belt tower, the power being transmitted to each room along a line of shafting. The whole arrangement occupies an area of 10 × 31 feet in the middle of the building, where the light is the poorest, being therefore the space least valuable. This method of interior construction, instead of being an added expense, cost $3,500 less than the estimates for a similar structure with joisted floors of equal strength and rooms of the same height in the clear. The rate of insurance is said to be the lowest ever given to a building under these conditions of occupancy, height and exposure to conflagration hazard.

The advantage of sound construction has never been more strongly illustrated than in Paris during the commune of 1871, when the mob sought to burn the city by the free use of kerosene, and only succeeded in burning the individual buildings which were set on fire, notwithstanding that there was no fire department to combat the fires. Photographs of streets taken after these fires show that the front walls of the burned buildings were still intact.

Experience has shown that the most effective measures against the fire hazard are those in the nature of precautions. The inception of fires should be guarded against by taking especial care of all matters tending to originate or spread fires; and, secondly, methods of construction which tend to prevent the spread of fire from one building to another, and also to retard the progress of a fire through the same building, should be used. The burning of material is simply the rapid oxidation which takes place when such material is raised to its ignition point in the presence of a supply of oxygen, and the combustion can be stopped only by removing one of these two essential conditions. The combustion of one pound of wood will produce 7,200 thermal units, and such combustion can be stopped by an amount of water which will absorb enough of the quantity of heat to reduce the temperature of the wood to below its ignition point, the smallest quantity of water being that which will be evaporated by the fire. To evaporate one pound of water at a temperature of 60° requires 1,119 thermal units, and, therefore, the amount of heat generated by the combustion of a pound of wood is sufficient to evaporate 6·43 pounds of water, and this is the minimum amount of water which will stop the combustion.

As a practical matter it requires the application of a much larger quantity of water to extinguish a fire. If the temperature of the water was increased 40° by the heat of a fire, 180 pounds of water would be required for every pound of burning wood. A fire in a cotton picker room was successfully put out by automatic sprinklers fed by an elevated tank, and it was found that 107⅜ pounds of water were used for each pound of cotton burned. The floors of all buildings, with the exception of dwellings, contain enough fuel in each floor to evaporate water to a depth of two or three feet upon the floor, without any reference to the combustible contents of the buildings. In the great fire at Lynn, November 26, 1889, enough water was used to cover the burned area of 40 acres to a depth of seven feet; and in the fire at Boston two days later, the amount of water used was sufficient to flood the area to a depth of 12 feet 7 inches.

[Continued from Supplement, No. 792, page 12650.]

GASEOUS ILLUMINANTS.*

By Prof. Vivian B. Lewes.

III.

The fact that coal gas of an illuminating power of from 14 to 16 candles can be made under ordinary circumstances at a fairly low rate, while every candle power added to the gas increases the cost in an enormous and rapidly growing ratio, has, from the earliest days of the gas industry, caused the attention of inventors to be turned to the enrichment of coal gas. This, up to the present time, has been almost universally carried out in practice by an admixture of rich cannel coal with the ordinary gas coal in the retorts, and a consequent heavy increase in the cost of the gas, a 16 candle gas made by either of the two large metropolitan gas companies costing about 1s. 2d. per thousand cubic feet in holder, while a 22 candle gas would be cheaply made at double that cost by the use of cannel. To make matters worse, cannel is rapidly increasing in price, and first class qualities are not easily obtained.

The methods which have from time to time been advocated to replace the use of cannel in the enrichment of illuminating gas may be classified as follows:

1. The carbureting of low power gas by impregnating it with the vapors of volatile hydrocarbons.

2. Enriching the gas by vapors and permanent gases obtained by decomposing the tar formed at the same time as the gas.

3. Mixing with the coal gas, oil gas, obtained by decomposing crude oils by heat.

4. Mixing with coal gas, water gas, which has been highly carbureted by passing it with the vapors of various hydrocarbons through superheaters in order to give permanency to the hydrocarbon gas. These methods must now be considered in detail.

1. Carbureting the gas by impregnating it with the vapor of volatile hydrocarbons.

The first attempt to directly carburet or naphthalize coal gas in a rational way was made by Mr. Lowe in 1832, who suggested that a form of wet gas meter should be employed, but that the liquid used in it should be the lighter hydrocarbons obtained by distilling coal tar instead of water, the idea being that the poor quality coal gas in passing through the volatile spirit would take up a certain quantity of the vapor, and so become enriched. Practice, however, soon showed that a number of unexpected difficulties existed. The apparatus required too much attention to keep the level of the liquid constant, and also to keep the meter and pipes clean; the gas, also, in passing through a fresh charge of liquid, took up so much of the hydrocarbon as to burn with a smoky flame, while after the gas had passed through the meter for some time, the illuminating power rapidly fell, and more harm than good was done to the gas. The process was also found to be too costly, and was rapidly abandoned.

Many inventors followed on the same lines, and in 1863, 1864, and 1865, the carbureting of coal gas was tried on a large scale, and many experiments were made by Dr. Letheby, who found that the quality of the naphtha employed had a marked bearing on the results obtained, as, although a naphtha with a low specific gravity and low boiling point yielded a large quantity of vapor to the gas, the illuminating value of it was very small; while naphthas with higher specific gravity and higher boiling point, although taken up to a far smaller extent, yet yielded a far higher illuminating power to the gas, this being due to the oils being mixtures of various hydrocarbons. If coal gas be passed through naphthas of various specific gravities, and the quantity taken up by the gas and the increase in illuminating power be determined, results are obtained as shown in the table, showing clearly that if a liquid hydrocarbon of fairly high specific gravity and a boiling point of medium height, which would evaporate sufficiently fast, could be obtained at a reasonable rate, it would be the best to use; as not only would the great danger attendant on the use of light naphthas be done away with, but the service obtained would be far higher and the quantity used far less.

It must be clearly borne in mind in approaching this subject that the evaporation of a hydrocarbon into a permanent gas, *i. e.*, a gas which does not liquefy within the ordinary range of temperatures, is neither a question of specific gravity nor of boiling point, although the latter has more to do with it than the former. It is purely a question of vapor tension. Most liquids when left to themselves, in contact with the atmosphere or other gases, gradually pass into the state of vapor and disappear, and those which evaporate the quickest are said to be the most volatile.

If ether is dropped upon an exposed surface it at once disappears, and causes by its evaporation considerable cold, and the lightest forms of naphtha do the same thing. Although this evaporation takes place with great rapidity in liquids of low boiling point, it must not be forgotten that many solids even have the same property, naphthaline, camphor, and iodine being cases which will occur at once to every one's mind; and it must also be remembered that evaporation occurs over a very wide range of temperature, but there is a limit for each substance, below which evaporation does not seem to take place. So that in considering the suitability of a liquid for carbureting in this way, it is far more important to determine its vapor tension than its specific gravity or its boiling point.

* Lectures recently delivered before the Society of Arts, London. From the *Journal* of the Society.

HYDROCARBONS FOR CARBURETING.

Specific gravity.	Boiling point. (Cent.)	No. of grains taken up by each foot of gas.	Percentage increase in illuminating power.	
			Total.	For each grain per cubic foot.
0·698	63	20·1	33·9	1·69
0·670	40	34·4	62·1	1·80
0·869	102	12·1	40·8	3·37
0·827	115	6·5	21·7	3·43
0·808	117	6·1	21·0	3·60
0·852	128	3·8	14·2	3·72
0·869	107	9·2	34·9	3·79
0·869	103	11·8	46·8	3·95
0·816	119	3·4	14·4	4·23
0·856	114	3·4	18·9	4·29
0·814	105	7·0	44·5	4·78
0·865	124	3·3	15·8	4·79
0·845	90	12·0	65·3	5·44
0·864	119	4·8	26·7	5·56
0·879	93	9·5	53·2	5·60
0·860	129	2·8	15·6	5·61
0·862	121	3·3	20·4	6·16
0·848	97	10·2	68·4	6·70
0·861	117	2·2	18·8	8·17
0·975	110	6·9	60·8	8·81

The great trouble which presented itself in the older carbureting systems was that all the commercial samples of naphtha are mixtures of various hydrocarbons having each their own boiling point, and that therefore, when used in any of the old forms of carbureter, they gave up their more volatile constituents very freely at the beginning of the experiment, while the amount rapidly diminished as the boiling point of the residue became higher; so that when 2,113 cubic feet of poor coal gas were passed through a naphtha having a specific gravity of 0·869 and a boiling point of 103° C., the temperature during experiment being 22° C.=72° F., the first 80 cubic feet of gas took up 23·2 grains of the naphtha, while the last 450 cubic feet only took up 7·3.

Another difficulty found was the increase of evaporation with increase of temperature, as with an ordinary form of carbureter exposed to atmospheric change, the enrichment of the gas, which reached 54·4 per cent. in summer, with an average temperature of 72° F. (22° C.), fell in winter to only 22 per cent., with an average temperature of 37° F. (3° C.)

Of course, in these carbureters, a good deal depended upon the form of apparatus; and it was found, on trying different forms with the same naphtha, that, when the gas merely flowed through a box containing a layer of it, only about 3·2 grains were taken up; while with a carbureter in which the naphtha was sucked up by cotton fiber, so as to expose a large surface to the gas, as much as 22 to 23 grains were taken up in the same period of time.

One of the most important points noticed during these experiments was that it was only a poor gas which could be enriched in this manner, and that if a rich cannel gas was passed through the naphtha, it was robbed of some of its illuminating power; a point also noticed and remarked upon by Mr. George Davis, in an important paper on the enrichment of coal gas, read before the Society of Chemical Industry on January 4, 1885.

Dr. Letheby's experiments were all directed to supplying the hydrocarbon to the gas at the burners just before consumption, but, as far as liquid hydrocarbons went, this was a failure at that time; and when revived on a small scale five years ago, it did not prove a very successful venture, although a liquid of more constant composition was employed. So far, the most successful method of carbureting gas at the burner has been that introduced by the Albo-Carbon Company in 1878, in which solid naphthalene is vaporized by the simple contrivance of letting the flame heat a small plate of metal which extends into the albo-carbon chamber, and so volatilizes the hydrocarbon and causes the vapor to mingle with the gas which is passing through the chamber. The naphthalene used in the albo-carbon system is prepared from coal tar, which is distilled, the first portion consisting of naphthas, etc., while the second portion is rich in phenols and cresols. The second distillate is again distilled, and the residue left becomes semi-solid, owing to the separation of naphthalene, which, on standing, separates and cakes on the top of the oil. This is then removed and pressed by hydraulic power in a hot press, each plate of which contains a steam pipe to heat it.

The crude naphthalene so obtained is then distilled, but contains a number of impurities which would cause it to turn yellow. To get rid of these impurities, it is melted and forced by steam pressure into a steam jacketed cylinder, where it is washed in dilute alkali, to get rid of phenol, and then four times with strong sulphuric acid, to remove sulphonates, metanaphthalene, etc., and is then water washed free from acid, these washings taking about seventy-two hours. The naphthalene now undergoes a final distillation, after which it is melted in steam jacketed coppers, and is ladled out and cast into sticks in an apparatus of the same construction as the old fashioned candle machines, these sticks being afterward cut into the smaller pieces used in the lamp reservoirs. This albo-carbon system has been entirely successful, and by it the illuminating power of coal gas can be increased nearly 60 per cent. The cost of naphthalene, or "albo-carbon," being something less than 3d. a pound, the process gives a very decided saving in expense, and is widely used, the only thing that can be urged against the system being the slight extra trouble

of each week charging the receiver with the naphthalene. This, in itself, would prevent this or any other system of carbureting at the burner from becoming a universally adopted process, as no amount of economy will persuade an ordinary English servant, or, for the matter of that, householder, to take a little extra trouble, and any system of carbureting, to be thoroughly successful, must be applied to the gas in bulk before distribution.

In doing this, there are two factors to be considered—the vapors added must be in such proportion to the gases which have to carry them that no fear need exist of their being deposited by any sudden cooling of the gas, and care must be taken that the vapor added is not in sufficient quantity to throw out of suspension the volatile hydrocarbons in the gas. The carrying power of a gas depends entirely upon its constituents; for in the same way that liquids vary in their power of dissolving and carrying (*i. e.*, keeping in solution) solids, so do gases vary in their power of bearing away the more volatile hydrocarbons.

If the carrying power of air be taken as unity, then the power of ordinary coal gas would be about 1·5, while hydrogen would be nearly 3·5; and it is manifest that attention must be paid to the ratio of the constituents present if gases of varying composition are to be carbureted to the same degree.

Mr. George Davis, in the paper quoted above, describes an experiment in which, while passing large quantities of a 17 candle gas through pure benzene, he found that, after four-fifths of the carbureting fluid had been taken up by the gas, the residual one-fifth had a far higher boiling point, and that this was due to such hydrocarbons as toluene and xylene deposited from the gas, showing that the gas exercises a selective absorption with the liquid hydrocarbons, and will deposit less volatile ones which it may be holding in suspension, in order to saturate itself with the more volatile.

It is thus seen that with an ordinary coal gas these factors would limit the degree to which carbureting could be carried, and there are not wanting indications that the limit would soon be reached. If a gas contains the vapor of a hydrocarbon liquid under ordinary conditions, the vapor will have a tendency to deposit under the influence of either cold or pressure, an exposed pipe in cold weather causing serious deterioration to the illuminating value of coal gas. Some very valuable experiments made by Mr. C. E. Botley show that when coal gas is compressed under a pressure of 13½ atmospheres, it loses about 17 per cent. of its illuminating power, and deposits about 5 oz. per 1,000 cubic feet of a liquid having a specific gravity of 0·870, and consisting largely of benzene and toluene. If, however, the gas is allowed to burn away, as the pressure falls so the illuminating power rises until, on reaching ordinary atmospheric pressure again, the gas has an illuminating power between 14 and 15 per cent. higher than the gas before compression, showing that the liquid hydrocarbons deposited under pressure were again taken up as the pressure fell.

During the past few months the idea of the feasibility of carbureting coal gas in bulk has again been revived by the construction of an extremely ingenious apparatus, the outcome of the combined engineering skill and practical experience of Messrs. Maxim & Clark, which obviates to a great extent the difficulties which arise with the older forms of carbureter.

It has been shown that, when carbureting a gas with gasoline or a light naphtha spirit, the more volatile portion enriches the gas to an undue extent at first, and that, as the process continues, the amount taken up gets less and less. This would not so much matter in carbureting the gas in bulk, before it went into the holder, as it would become, to a great extent, mixed by diffusion, and a gas of fairly even illuminating power would result. But the Maxim-Clark apparatus is intended to not only do this, but also to carburet the gas used in large establishments and works, and it must, therefore, be so arranged as to supply each portion of gas passing through it with its own particular share of hydrocarbon, and not allow the selective absorption of the more volatile constituents by the first samples of gas.

For small installations, the apparatus consists of a circular copper retort, which is kept automatically filled to a fixed level from a reservoir outside the building filled with gasolene. The copper retort is jacketed, and steam or hot water is passed round it, which volatilizes the gasolene; this passes over baffle plates in the top of the retort, and then through an automatic regulator into a small holder, which works like a gasometer, sealed in mercury. The gas to be carbureted has to pass through this holder, and as it does so, the gasolene vapor is supplied to it in the following way:

The holder works on a vertical spindle, which passes down the tube into the gasolene retort, and is so arranged that when the holder is grounded, *i. e.*, when no gas is passing through, the opening is closed, and no gasolene can pass into the holder. As gas is admitted, so the holder rises, and lifts the spindle with it, allowing the gasolene and vapor to push up through grooves cut in the bottom of it, which increase in size the higher the spindle is drawn, and so allow more gasolene to pass into the holder the more gas passes through.

It is found inadvisable to carburet a 16 candle gas higher than above 40 candle power, as up to this point it can be burned from an ordinary small burner consuming two cubic feet per hour. The gasolene used is light petroleum spirit, having a specific gravity of about 0·650; and experience shows that when ordinary 16 candle coal gas is carbureted, the illuminating power is raised one candle power for each pint per 1,000 cubic feet.

The apparatus I have thus described, however, cannot be made on a sufficiently large scale to carburet gas in very great bulk; besides which, if a gas manager has a gasometer full of gas, the illuminating value of which is dangerously near the prescribed limit, it is evident that there is likely to be no room to mix in a sufficient quantity of the highly carbureted gas to bring up the illuminating power to the required standard, while, if there were room, diffusion would be so slow that practically the gases could not be given time to mix.

In order to obviate this trouble, Messrs. Maxim & Clark have devised an apparatus which will take a certain portion of gas out of the main, enrich it, and again return it to the main, and there mingling with the steady flow of gas, the whole becomes mixed. In this way, experiments made by Mr. Livesey, of the South Metropolitan Gas Company, show the system to be not only feasible but very convenient, and the ordinary coal gas, enriched to the extent of two candles, will retain the extra hydrocarbons perfectly well.

At the present time, the cost of enriching a 17 candle gas up to 18 candle, by the use of cannel coal, amounts to 2½d., while the cost of doing the same thing with gasolene would probably not exceed 1¼d.

From the earliest days of the gas industry attempts have been made to utilize tar for the production and enrichment of gas, and the patent literature of the century contains many hundreds of such schemes, most of which were stillborn, while a few spent a short and sickly existence, but none achieved success, and the reason of this is not difficult to understand.

In order to make gas from tar two methods may be adopted: (1) To condense the tar in the ordinary way, and afterward to use the whole or portions of it for cracking into a permanent gas; or (2) to crack the tar vapors before condensation by passing the gas and vapors through superheaters.

If the first method be adopted, the trouble which presents itself, and in a few hours brings the apparatus to grief, is that tar contains 60 per cent. of pitch, which rapidly chokes and clogs up all the pipes; while if an attempt is made to use a temperature at which the pitch is decomposed, then it is found that a non or very poorly luminous gas is the result, while a heavy deposit of carbon remains in the superheater or retort, and even at high temperatures easily condensible vapors escape which afterward create trouble in the pipes.

In order to get over the trouble arising from the choking by the pitch, attempts have been made to distill the tar at a low temperature, and utilize the 40 to 50 per cent. of oil so obtained for gasifying; but here the small yield of oil, and the expense of handling and distilling, have prevented tar from competing with coal as a source of gas.

A more economical way of doing this was to distill the tar so as to leave the pitch behind, and then instead of condensing the vapors to oil, to pass them through a heated chamber, which should convert them into permanent gases; but as soon as this was tried it was found that the lighter vapors, which distilled off first, only required a temperature to crack them which was totally inadequate to render the heavier vapors coming off later in the distillation permanent, so that they condensed to liquids; while if the heat was so arranged as to crack the heavy vapors, it broke up the lighter ones into gases of a very poor illuminating power.

These troubles, of course, arise from the same cause as in the earlier experiments on carbureting gas by passing over or through volatile naphthas—that is, that the tar, like the naphthas, is a mixture of many compounds varying in composition and properties.

In order to (as far as possible) get over this trouble, Mr. George Davis proposed in a paper read before the Society of Chemical Industry to distill the tar, so as to remove pitch, and then to get rid of the naphthalene and anthracene, using the remainder, four-fifths of which can be gasified, for enriching the gas.

He calculates that coal yields 0·7 per cent. of its weight of tar, and that 0·42 of this is got rid of as pitch, while the remaining 0·28 per cent. can be converted into gas, a gallon of this oil yielding 80 cubic feet of 50 candle gas, and he infers from this that from a ton of ordinary coal, by utilizing the tar in this way, 10,465 cubic feet of 18·4 candle gas could be obtained, instead of 10,000 of 17 candle gas.

The success of such a process must, however, entirely depend upon the value of tar and the cost of cannel in any given locality, as the expense of the process must of necessity be considerable.

The most successful attempt to utilize certain portions of the liquid products of distillation of coal is undoubtedly the Dinsmore process, in which the coal gas and the vapors which, if allowed to cool, would form tar are made to pass through a heated chamber, and a certain proportion of otherwise condensible hydrocarbons are thus converted into permanent gases. Using a poor class of coal, it is claimed that 9,800 cubic feet of 20 to 21 candle gas can be made by this process; while, by the ordinary process, 9,000 cubic feet of 15 candle gas would have been produced.

In the center of each bed of six retorts an empty retort, called the duct, is fixed; and through this the whole of the gas and vapor produced in the other retorts has to pass before reaching the hydraulic main.

The duct is kept at a bright cherry red heat at the entrance (1,700° F. = 926° C.) and at a dull red at the exit end (1,200° F. = 639° C.), this gradation of heat being important, as, if it were at a high heat throughout, the hydrocarbons would be over-cracked, and a loss of illuminating power would be the result.

From the duct an ascension pipe leads the gas to the main by means of a bridge pipe, and this ascension pipe is provided with a water jacket, which causes liquid tar to condense and renders any condensed pitch or carbonaceous matter sufficiently liquid to slide back down the pipe, and so prevent any chance of choking.

Each retort in the bench, besides having a connection with the duct, is also connected with the hydraulic main in the usual manner, but is closed by a heavy seal. One retort of the bed of six is drawn and charged hourly, and as each retort is heated for six hours, and as the products of distillation vary according to the period for which the retort has been heated, this arrangement keeps the average composition of the gases mingling in the duct fairly constant.

The quantity of tar produced by this process is roughly about two-thirds of the quantity made in the ordinary way, and is, moreover, very poor in light oils and tar acids, so that there can be but little doubt that the hydrocarbons and phenols are broken down into olefines and acetylenes.

An analysis of the Dinsmore gas shows the composition as:

Carbon dioxide	0·23
Illuminants	6·76
Carbon monoxide	8·10
Methane	40·34
Hydrogen	43·98
Nitrogen	0·59
	100·00

Specific gravity	0·428
Illuminating power (candles)	22·3
Carbon density	2·96
Hydrogen density	5·80

In distilling the coal in the ordinary way, the yield of tar is 11 gallons per ton; but by the Dinsmore process only 7 gallons. On examining the analysis of the ordinary and Dinsmore tar, it is at once evident that the 4 gallons which have disappeared are the chief portions of the light oils and creosote oils; and these are the factors which have given the increase of illuminating power to the gas. As pointed out by Prof. Foster, it is unfortunate that there are no figures to be obtained showing the differences in the gas and tar produced when the same coal is worked side by side by the ordinary and Dinsmore processes, as this would not only be of great scientific value, but would also clearly demonstrate the value of the process.

We must now consider the third method by which a poor coal gas can be carbureted—viz., by mixing it with oil gas obtained by cracking crude oils by heat. Experiments in this direction have lately been instituted—first by Mr. Good, at Carshalton, and more recently by Mr. Herring, at Dover. To carburet a gas directly by oil, the paraffin is injected into the retort under a slight pressure—not less than 15 lb.—so that the oil is sprayed on to the red hot coke, and, cracking, yields oil gas, which mingles with the coal gas. In making a carbureted gas, it is far better to crack the liquid hydrocarbon in the presence of the diluents which are to mingle with it and act as its carrier; as, if this be done, a higher temperature can be employed, and more of the heavier portions of the oil converted into gas, without, at the same time, breaking down the gaseous hydrocarbons too much. For instance, if a petroleum oil is cracked by itself, the resulting gas would consist largely of hydrogen and methane, and the heavy hydrocarbons would probably vary from 16 to 26 per cent.—a considerable quantity of carbon separating; while, if cracked in the presence of a stream of diluting gas, a far higher percentage of illuminants of the higher marsh gas series (ethane, etc.) would be produced, and a comparatively small quantity of hydrogen and methane. This is due to the same cause as the non-luminosity of the Bunsen burner—*i. e.*, that when the hydrocarbons are undiluted, they can easily be broken down to hydrogen and carbon; whereas, when they are diluted, a far higher temperature is necessary to effect this action, and so the degradation of the hydrocarbons is stopped at an earlier stage.

In carbureting a poor coal gas with paraffin, it must be borne in mind that, as the coal is undergoing distillation, in the earlier stages a rich gas is given off, while, toward the end of the operation, the gas is very poor in illuminants and rich in hydrogen; the methane disappearing with the other hydrocarbons, and the increase in hydrogen being very marked. Mr. Lewis T. Wright employed a coal requiring six hours for its distillation, and took samples of the gas at different periods of the time. On analysis, these yielded the following results:

TIME AFTER COMMENCEMENT OF DISTILLATION.

	10 min.	1 h. 30 m.	3 h. 25 m.	5 h. 35 m.
Sulphureted hydrogen	1·30	1·42	0·49	0·11
Carbon dioxide	2·21	2·09	1·49	1·50
Hydrogen	20·10	38·33	52·68	67·12
Carbon monoxide	6·19	5·68	6·21	6·12
Marsh gas	57·38	44·03	33·54	22·58
Illuminants	10·62	5·98	3·04	1·79
Nitrogen	2·20	2·47	2·55	0·78

This may be regarded as a fair example of the changes which take place in the quality of the gas during the distillation of the coal. In carbureting such a gas by injecting paraffin into the retort, it would be great waste to do so for the first two hours, as a rich gas is being given off which has not the power of carrying a very much larger quantity of hydrocarbons from being practically saturated with them. Consequently, to make it take along with it, in a condition not easily deposited, any further quantity, the paraffin would have to be broken down to a great extent; and the temperature necessary to do this would seriously affect the quality of the gas given off by the coal. When, however, the distillation had gone on for three hours, the rich portions of the coal gas would all have distilled off, and the temperature of the retort would have reached its highest point; and this would be the time to feed in the oil, as, its cracking being an exothermic action, the temperature in the retort would be increased, and the gas rich in hydrogen which was being evolved would carry with it the oil gas, and prevent any redeposition.

In conclusion, it is unwise, in carbureting gas, to make a large quantity of a poor gas, and then expect to enrich it with a certain quantity of rich gas by allowing the two to mix in the holder, as, under these conditions, the mixing has to be done by the diffusion of gases, which takes place at a rate inversely proportional to the square root of their densities, with the result that a very heavy and a very light gas quickly mingle. Where, however, there is a rich gas with say a specific gravity of 0·515 and a poor one of 0·422, the difference in density is so slight that there is practically no tendency to mix; and the contents of the holder would remain in layers of the original gases, with thinner layers of mixed gases between them.

(*To be continued.*)

ACCORDING to *Le Mercredi Medical*, Dr. Pohl, of St. Petersburg, believes that certain crystals found in semen are, as stated by Schreider, the phosphate of an organic base, spermine, that is identical, according to Laderberg and Obel, with ethylenimine. Dr. Pohl has extracted spermine from the testicles of young rabbits, and finds experimentally that it decreases the action of the heart while it increases general energy and stimulates the nervous and genital systems. He believes that the action of castoreum and musk is due to the presence of spermine.

APPARATUS FOR TAKING DISTANCES AT SEA.

This apparatus, called by its inventor a "range finder," is, as its name indicates, designed for quickly giving at sea the distance of a certain object, say a ship or lighthouse, and is, therefore, by reason of this property, destined to render great services on board of vessels, principally on ships of war, upon which the accurate estimation of distances constitutes one of the most important conditions for accuracy in firing.

After having been successively tested in the American and the Russian navies, this apparatus is about to make its advent upon one of our Mediterranean armorclads, and the moment is, therefore, opportune for giving our readers a description of it.

It consists, in principle, of two powerful telescopes capable of moving along two arcs of conductive metal

Fig. 1.—MODE OF USING THE RANGE FINDER.

whose extremities are connected with the circuit of a battery through the intermedium of the arrangement known in physics as the Wheatstone bridge.

Fig. 2 will permit of the arrangement being understood. The two telescopes, C and D, pivot around the points, A and B, and their extremity moves along the metallic arcs, E and F. The current from the pile, *h*, passes through the pivots, A and B, of the telescopes, and then into the arcs. From F it circulates in the wires *b* and *d*, from E in the wires *a* and *c*, and traverses the special galvanometer, G, which is the important part of the apparatus.

Let us suppose that we wish to measure the distance at which a point, T, is situated. The two telescopes being directed to this point, we at once see that the distance, A T, sought is given by the trigonometrical formula—

$$\frac{A\,T}{\sin B} = \frac{A\,B}{\sin T}$$

calling A, B, T the angles corresponding to the apices of the same name of the triangle, A B T. Whence

$$A\,T = \frac{A\,B}{\sin T} \times \sin B$$

As we know the distance, A B, the problem consists in seeking the angles, T and B.

For simplicity, let us first suppose that the angle B be a right one, as is the case in our figure. The sine is then equal to 1, and it only remains to seek the sine T. Now, in order to bring the telescope C in the direction A T, it has been necessary to cause it to revolve in such a way as to make it take the position C'. A simple inspection of the figure will show that the angle C' A C that the new position of telescope makes with the former one is equal to the angle T, and the reading of this angle is at once made upon the dial E. But, in practice, this peculiarity of B T at right angles with A B can evidently present itself but rarely. We shall, therefore, examine the general case, in which the angles may be of any kind whatever.

Let us remark, in the first place, that, when the two telescopes are parallel, the equilibrium of the Wheatstone bridge is complete, and consequently the needle of the galvanometer shows no deflection. This equilibrium occurs, moreover, whatever be the position of the telescopes on the dial, provided that they are perfectly parallel. But if the telescope C, for example, be made to pivot in order to bring it to C', the parallelism being destroyed, and, along with it, the equilibrium of the two parts of the bridge, the needle of the galvanometer will undergo a deflection. This latter will be so much the greater in proportion as the arc described by the telescope is greater, that is to say, the distance A T will be shorter.

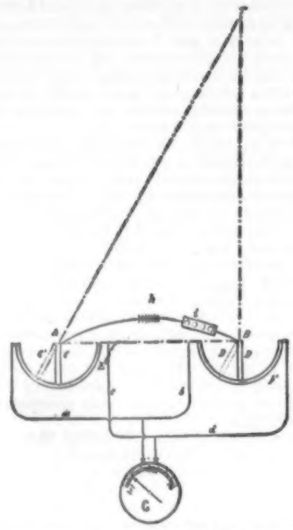


Fig. 2.—DIAGRAM OF THE RANGE FINDER.

It will be seen, then, that the deflection of the galvanometer, which is *nil* for an infinite distance, continues to increase in measure as the distance diminishes. If, then, the galvanometer (and it is the case in this apparatus) is so graduated that the deflections of the needle are proportional to the differences of potential at the terminals, it may be seen that the distance A T can be read directly upon the scale with which the galvanometer is provided. It will suffice to correct this reading by multiplying it by the sine B, in order to ascertain the displacement of the telescope, D. The angle, B, is read upon the dial, F.

In what precedes, we have supposed that the resistance in the circuit is constant, and equal when the two telescopes occupy the two parallel positions C and D. That is not so in reality, and the relation between the resistance of the part, A B, and the resistance of the current varies with every position of the telescopes. But it may be seen that if we introduce a strong resistance, I, between A and B, the variation of the preceding relation may be considered as of no account as regards its action upon the indications of the galvanometer.

Fig. 3 shows the installation of the apparatus upon the deck of a ship for right and left observations. One of the telescopes is installed in the fore part of the ship, and the other aft. When it is desired likewise to make fore and aft observations, a second apparatus is installed upon the bridge.

Fig. 1 shows the apparatus in service. The operator, on applying his eye to the ocular of the telescope, has opposite to his mouth a telephone transmitter, the receiver of which is hooked to the same support, within reach of his hand. Owing to this arrangement, the two operators are in constant communication with each other and with the officer who has to note the indications of the galvanometer. In this way are avoided the errors that might be caused by the reading of a deflection produced before one or the other of the telescopes is well directed toward the point to be observed.—*Les Inventions Nouvelles.*

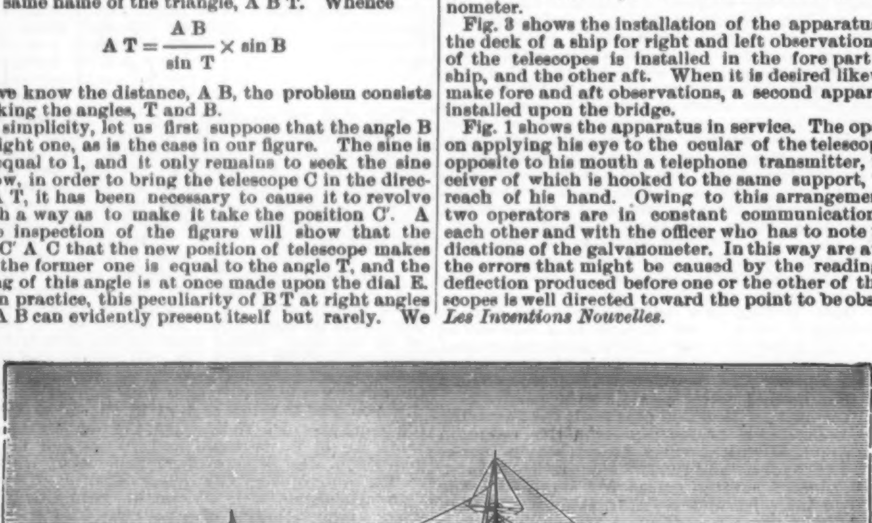


Fig. 3.—RANGE FINDER INSTALLED UPON A SHIP.

PECULIARITIES OF LEATHER.

The hides of steers or heifers make the best of all harness leather when well tanned with oak bark, which imparts a light brown color to the leather, makes it firm, with an even grain and to a certain extent allows the hide to retain its softness. The skins or hides, technically called "pelts," are first softened by being soaked in water, after which they are piled in lime pits to loosen the hair. Instead of placing them in lime some tanners hang them in heated rooms, where they begin to putrefy, and in this state the hair is easily removed; however, neither process should be carried too far, or the grain will be injured, in which case a good finish is impossible; besides, lime is apt to make the leather harsh and brittle. Following the removal of the hair the hides are placed for a short time in a weak mixture of bark and water, termed "liquor," and from time to time they are moved into liquors gradually increased in strength until they have been in the various pits from ten to eighteen months, according to the thickness of the hides and the conscience of the tanner.

There are many other methods employed in tanning leather, among which we may name those known as "Hemlock" and "Union" tannage, but these and all the other numberless ways of tanning produce a rough hide, which, when curried, does not absorb the dubbing, and will not stand wear at the buckles. Moreover, this leather almost invariably swells after being exposed to rain. The reason why so much of this leather is tanned is because the process is much cheaper and is carried out in as many weeks as good bark-tanned leather takes months, but, as I have said, there is no tannage equal to oak bark. By its use we obtain the lightest, strongest, and most pliable leather. It yields a closer grained leather, which, when wet, dresses softer than any other, and to sum up its good qualities, we have only to add that it is easier to work, and takes a better and more even color than either of the other varieties.

For the different grades of harness, such as gig, brougham, etc., a correspondingly heavy grade of leather is used in order that the traces and strapping may possess the requisite strength and substance. After tanning, the hide is termed "rough leather," and from this the various kinds of leather are produced.

Merely tanning leather will not, however, fit it for the harnessmaker's use, and it must be subjected to another process termed "currying," by which the leather is made soft, pliable, and durable. The hide, being thoroughly soaked in water, is placed over a beam and the surplus flesh is taken off with a knife. As harnessmakers require their hides as level as possible, those which are naturally level, free from cuts, worm bumps, coarse necks, etc., are chosen for the best harness and rein leather, and, being exceedingly difficult to obtain, they are worth 20 per cent. more than an ordinary hide of equal weight. Shaving the hide to make it level is the most critical part of currying, as, if the shaving is carried the smallest degree beyond what the hide will bear, the leather is made "loose." This process is followed by the hide being scoured on both flesh and grain side in order to take out the "bloom" and dirt, by which means alone can good and regular color be insured. These measures also facilitate the stuffing process, which consists of the hide being well set out on a table and the application of the dubbing (a mixture of tallow and cod oil) in such proportions as the substance or thickness of the hide may necessitate. Following this, it is hung up to dry, or rather to allow the dubbing or oils to penetrate every pore, whereby the hide is rendered pliable and durable and in a state to resist wet.

It is unnecessary to trouble the reader with all the details of dressing black or brown harness leather, but, generally speaking, it consists of shaving, scouring, stuffing, and blacking, if for black harness; or staining with various ingredients if required for brown. In this state it reaches the harnessmaker, and he can express an opinion on its adaptability to his purpose, but no matter how wide his experience, he cannot impart to others any rules by which they can select good leather. Practice is the only thing that will enable them to accomplish it with certainty. Good leather is defined as being solid, but not hard; mellow, but not soft; qualities that cannot be explained, but which can be detected instantly by any one who has the requisite experience.

The properties of leather may be completely spoiled by injudicious cutting, and the workman who performs this operation must, above all things, have sufficient experience to enable him to so manipulate the leather that the grain shall always run parallel to the cut, otherwise the leather will stretch directly it comes into use, and continue to do so.

Brown leather, which we use for reins, is in every respect the same as harness leather, except in color, it being bleached instead of being blackened, and afterward stained a light shade of brown. There is no part of the harness leather subject to such severe criticism as that composing the reins, and any defect in strength, cutting or uniformity of color may be said to spoil them. The hand parts especially should possess in great perfection the qualities of softness and pliability.

Buff leather (called by some buckskin) hand parts are sometimes used. In making this leather the currier buffs, *i. e.*, beats out, the grain until it cannot be recognized. This gives the leather a furried appearance, devoid of gloss, like chamois skin.

Buff leather hand parts are occasionally japanned white on one side and are then called "patent;" but when the reins are stretched by use the japan or varnish cracks, and the appearance is consequently anything but seemly.

Rein hand parts are occasionally made of white leather, which we obtain from the hide of the horse, bleached and dressed in a solution of alum and other ingredients to preserve it. White leather hand parts, however, are not fashionable at present, and it is more generally used for whip thongs.

Hogs hide is made in the ordinary way from the skin, of the hog, hence the name pigskin as applied to riding saddles. The most peculiar feature of this leather is that it is never made rough by friction. Imitation hogskin is made in large quantities, but as the bristles of the pig reach completely through the skin, there are holes on the flesh side of the genuine article, whereas those in the imitation only reach par-

tially through the hide. Hogskin is utilized for the pads, winkers, etc., of brown harness, which, owing to its light and showy appearance, is admirably suited for sporting carriages.

Japanned or, as it is more familiarly known, patent leather is made from specially selected hides tanned with more than ordinary care. After being tanned the hide is split by a machine knife, some hides yielding two and some three splits, according to the thickness of the leather, the grain side being used for enamel leather. The manufacture of patent leather includes several processes of a delicate nature, chief among them being the application of the varnish, to receive which the hide is sleeked out tightly on a board with the edges nailed down. The quality of patent leather is so much dependent on the state of the atmosphere when japanned that it is a very uncertain article; and, as all consumers know, nothing looks worse than cracked patent leather.

The careful selection of leather suitable for the different parts of harness is an important consideration with the harnessmaker, and he is ever careful to reject any hides that have been cut or otherwise injured in the currying, or any having warbles. The presence of warbles in light strapping is sufficient to condemn it at once, especially if near the edge, when it is never safe. There is an excellent and very simple way of determining the tannage by examining the edge of the strap when newly cut. If well tanned the whole edge will show a uniform light shade of brown right through; but if the color is a light hard yellow toward the center, it shows that the tannin has not penetrated, and if the edge of the strap under examination is slightly damped, the difference in color will become very distinct. Leather that has been tanned with chemicals is usually red in color, but may be bleached to resemble oak bark tan. When chemicals are used the natural strength of the hide is usually destroyed in the tan pit, and though such leather is materially cheaper than oak tanned, it is very much less durable and will not bear the same strain. Moreover, properly tanned leather bears a bright gloss when cleaned up, very different to the harsh dry appearance of inferior tannage.—*J. P., Harness.*

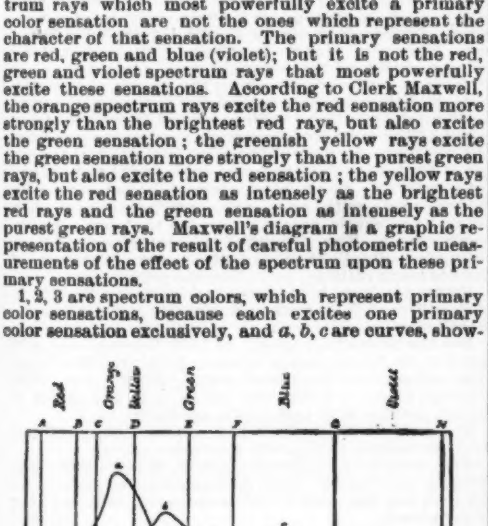
PHOTOGRAPHY IN THE COLORS OF NATURE.*

By F. E. IVES.

THIS new principle, first stated by me in a communication to this institute on November 21, 1888, is that of making sets of negatives by the action of light rays in proportion as they excite primary color sensations, and images or prints from such negatives with colors that represent primary color sensations.

In order to understand this principle, I must explain that, although the spectrum is not made up of three kinds of color rays and mixtures thereof, the eye is only capable of three primary color sensations—a distinction of the utmost importance, for the reason that the spectrum rays which most powerfully excite a primary color sensation are not the ones which represent the character of that sensation. The primary sensations are red, green and blue (violet); but it is not the red, green and violet spectrum rays that most powerfully excite these sensations. According to Clerk Maxwell, the orange spectrum rays excite the red sensation more strongly than the brightest red rays, but also excite the green sensation; the greenish yellow rays excite the green sensation more strongly than the purest green rays, but also excite the red sensation; the yellow rays excite the red sensation as intensely as the brightest red rays and the green sensation as intensely as the purest green rays. Maxwell's diagram is a graphic representation of the result of careful photometric measurements of the effect of the spectrum upon these primary sensations.

1, 2, 3 are spectrum colors, which represent primary color sensations, because each excites one primary color sensation exclusively, and *a*, *b*, *c* are curves, show-



ing the relative power of spectrum rays to excite the respective sensations.† These conclusions are stated and indorsed in all recent text books on color, and that eminent physicist, Lord Rayleigh, goes so far as to say that the theory is as well proved as the law of gravitation.

The carrying out of my new principle, according to Maxwell's measurements, therefore, involves the production of one negative by the joint action of the red, orange, yellow and yellow-green rays, in definite proportions, to represent the red sensation; one by the joint action of the orange, yellow, green and green-blue rays, in definite proportions, to represent the green sensation; and one by the joint action of the blue-green, blue and violet rays, in definite proportions, to represent the blue sensation.

Negatives of the required character can be made by exposing a cyanine-stained gelatine bromide plate through a double screen of chrysoidine orange and aniline yellow of suitable intensity for the red sensation, a cyanine erythrosine gelatine bromide plate through a screen of aniline yellow of suitable intensity for the green sensation, and an ordinary gelatine bromide plate through a double screen of erysophenine yellow and RR methyl violet for the blue sensation. The plates and screens are correct when they will secure negatives of the spectrum showing intensity curves substantially like the curves in Maxwell's diagram. The negatives can also be made on certain makes of ordinary commercial gelatine bromide plates of the most rapid kind, by the use of quite different color screens for the first two, but only with exposures of from five to fifteen minutes on well lighted landscapes, aperture of objective *f*. 12.

In photographing objects in a changing light, landscapes, for instance, it is important that the three sensitive plates be exposed simultaneously; and in order to accomplish this, I devised a triple camera, having three lenses so arranged in connection with reflectors as to bring all the points of view within a one inch circle. With this camera, the production of sets of negatives of the required character is a simple and easy matter, it being only necessary to insert the plates, raise the flap until the exposure is made, take the plates out again, and, when convenient, to develop them together, in the ordinary way.

There are two ways of making the heliochromic pictures from these negatives. The first method does not produce a permanent picture, but a screen projection.

Lantern slides made from the heliochromic negatives and exactly reversing their light and shade must also represent the effect of the object upon the respective color sensations. One lantern positive, when seen by transparency in red light, reproduces the effect of the object upon the primary red sensation. Another, viewed in the same manner by green light, reproduces the effect of the object upon the green sensation. The third, viewed by blue violet light, reproduces the effect upon the blue sensation. Evidently the combination of these three images into one must form a reproduction of the object as seen by the eye, correct in form, color, and light and shade. Such a combination is effected by projecting the three pictures with a triple optical lantern, so that they exactly coincide upon the screen. The result is what we have been led to expect.

We have here a true solution of the problem of reproducing the colors of nature in a screen picture, dating from November, 1888. Previous to the publication of my new principle, it was assumed by Cros, Poirée and others, that if the projection method were employed, each picture should be projected by the same kind of rays as those which acted to produce it. In my method, as I have already stated, a picture made by the joint action of red, orange, yellow and yellow-green rays, but chiefly by orange, instead of being projected by a similar mixture of spectrum rays, is projected by red rays only. Similarly, the picture made by orange, yellow, green and green-blue rays is projected by green rays only, and that made by blue-green, blue and violet rays, by blue-violet rays only. That is the true principle, yet nothing of the kind had ever been suggested. The process is capable of giving results which are above criticism, except of that hair splitting kind which applies also to the ordinary photographic process as a means of reproducing objects which have no color. The most serious objection to this method of solving the problem is that its only commercial value would lie in its application to the illustration of popular lectures.

Dr. Stolze, who was one of the first to recognize the genuineness of this solution of the problem, doubted if, even in theory, color prints from the same kind of negatives could be made to furnish such a perfect solution. A year ago, I also believed that there were theoretical difficulties in the way of realizing a perfect process with color prints. Only recently have I succeeded in showing what relation the colors of the prints must bear to the colors of light used in projection, in order to perform exactly the same function and, under like conditions of illumination, secure equally perfect fulfillment of theoretical requirements.

In the projecting method, we build up the luminous image by adding light to light. White light is produced by the mixture of the three colored lights used for projection, and black by their suppression. But when we carry out the process to produce permanent pictures, the paper which may form the basis of the picture is itself white, and it is the shadows that are built up by the superposition of color prints.

Nevertheless, the color print has exactly the same function to perform as the lantern positive, *i. e.*, to absorb and suppress, by its shading, light affecting one primary color sensation. If we remove our three positives from the lantern, the screen is evenly illuminated with white light. If we then replace the one representing the green sensation, its shadows will absorb the green light, with the result that the screen bears a picture in the complementary color, pink, on a white ground.

In the color print method, we commence with a white surface, which corresponds to the fully illuminated screen, and the shadows of the color print representing the green sensation, when laid upon this surface, absorb the same kind of rays as the shadows of the positive in the lantern, and with the same result, a pink monochrome picture on a white ground. Superposing the other two color prints upon the first one on paper is like inserting the other two positives in the lantern. This explains why the primary sensations are represented by prints having shades of the complementary (absorbing) color. It is the lights and not the shades of the color prints that represent the effect upon the respective primary color sensation. It is only necessary to use dyes that completely absorb red light but neither green nor blue-violet for the print representing the red sensation, green but neither red nor blue-violet for the green sensation, blue-violet but neither red nor green for the blue sensation, in order to obtain from my negatives a color print heliochrome that exactly fulfills all theoretical requirements, provided that it be examined in the same kind of white light that we obtain in the screen projections, by mixing red, green and blue-violet rays. The dyes mentioned by me in my paper of November 21, 1888 (Prussian blue, aniline magenta and aniline yellow), fulfill this requirement, and color print heliochromes made therewith according to my instructions must, therefore, reproduce all the colors of nature under the conditions of illumination just stated.

We have, then, a theoretically perfect and, at the same time, practicable process of reproducing all the colors of nature in permanent prints from three negatives.

In order to obtain colors that would appear of exactly the right kind and shade in ordinary white light, it would be necessary to use dyes each of which completely absorbed all light affecting the color sensation which it represented, but no other. The colors would then be correct in ordinary white light, but would appear too dark relatively to the white ground. In order to obtain colors that appear brighter in ordinary white light, dyes may be used which completely absorb only rays that excite chiefly single primary sensations and other rays in due proportion. The dyes proposed by me also fulfill this requirement, so that even in ordinary white light the degradation of a color is insignificant, except in the greens, where it is noticeable.

In the composite heliochromes by my process, which I show to-night, the colors are, as you can see, as perfect in detail and gradation as the monochrome shades of an ordinary photograph.

In conclusion, for the benefit of those who would like to know why this process is not now in commercial operation, having been perfected in theory three years ago, I will say that, for various reasons, it is not practically available to one whose time is nearly all taken up with a business of a different character, and I do not expect to do much with it until I shall have completed preparations which will justify me in making it my chief occupation. In order to carry out the process in strict accordance with the theoretical requirements, means must be employed not only to secure three negatives and three prints, each of which is correct by itself, but each must bear also a certain definite relation to the others. A very little over or under exposure of any one color print, or a very little too much or too little of the color stuff in the film, will change the shade of delicate colors. Fortunately there is a simple optical test by which such a defect can be detected without reference to, or knowledge of, the colors of the object photographed; but at present it is difficult to secure such harmony of parts when but little time can be spared to devote to the operation of the process.

Composite heliochromy must always remain a comparatively costly process, when carried out in a manner calculated to yield the finest results, and can most profitably be brought before the public in the form of optical lantern lecture illustrations, not with the triple lantern, but with transparent color print heliochromes mounted as lantern slides. If the color prints are made by the Woodburytype process, such heliochromic lantern slides, infinitely superior to hand painted ones, can be made in quantity at a cost not exceeding one dollar each.

* Abstract from a lecture before the Franklin Institute, Dec., 1890.

† Taken separately, each of these curves is probably correct; but the three do not compound to represent accurately the relative visual intensity of different parts of the spectrum, because the curve of the green sensation is relatively too low, and that of the blue sensation too high; if the curve of the green sensation be drawn as high as that of the red, and the height of the blue curve be reduced one-half, they will compound to represent fairly a photometric measurement of the visual intensity of the spectrum.

PLAIN PHOTOGRAPHS PROJECTED IN COLORS.

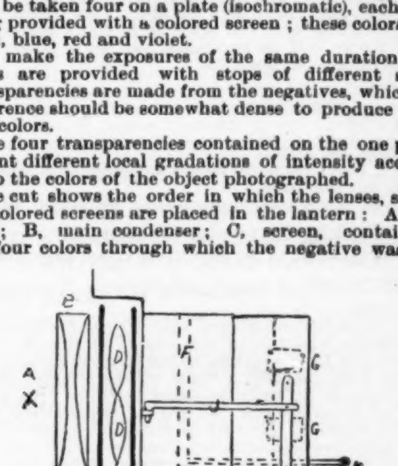
THROUGH the kindness of the inventor, Mr. Albert Scott, of Weston-super-Mare, we have had an opportunity of examining and trying his new lantern, which is termed the Verak. The general arrangement displays great ingenuity, and the results as seen on the screen are very striking.

In order to see transparencies in color, negatives must be taken four on a plate (isochromatic), each lens being provided with a colored screen; these colors are green, blue, red and violet.

To make the exposures of the same duration the lenses are provided with stops of different sizes. Transparencies are made from the negatives, which by preference should be somewhat dense to produce brilliant colors.

The four transparencies contained on the one plate present different local gradations of intensity according to the colors of the object photographed.

The cut shows the order in which the lenses, slides and colored screens are placed in the lantern: A, the light; B, main condenser; C, screen, containing the four colors through which the negative was ex-



posed; D, set of four auxiliary condensers; E, the Verak slide; F, registering lens; G, four projecting lenses; H, lever for focusing; I, sliding tube containing the four lenses; J, fulcrum for focusing lever; K, rod by which F is moved.

The transparencies are placed respectively in front of the same colors through which they were photographed, and when they are projected on the screen, may at first present the appearance of four pictures in the different colors in a confused state. These are registered by moving the handle, H, sideways, parallel with the screen, which gives a twist to the tube, I, while they are finely adjusted or centered by pushing in or withdrawing K, which actuates the lens, F. In the case of a photograph of a shop front, the various colors of goods in the window presented a fine appearance, the different colors being well depicted.

Owing to the density of the colored screens through which the light has to penetrate, a strong illuminant must be employed. With a blow-through jet we obtained pictures about 4 feet square, but with a mixed jet of large bore there is no reason why a picture twice the size should not be produced; but in this case the audience would require to be some distance from the screen so as to overcome the difficulty of exact registration, for it must be remembered that the pictures being taken from points slightly apart, *absolute* registration is impossible, but by confining the projected pictures to somewhat small diameter, this defect is lessened, and unless viewed at close quarters it is not noticeable.

In the 4 foot picture spoken of, the lantern was placed about 10 feet distant, while the pictures looked best from a distance of several feet beyond this.

We projected about two dozen slides, which Mr. Scott informs us are *apprentice* work, but after one gets fairly in working order, there is no doubt that very fine results can be obtained.

Arrangements are being made to publicly exhibit the effects produced by the Verak, and those who are privileged to be present will see something of a decidedly novel character.—*Magic Lantern Journal.*

[Continued from SUPPLEMENT, No. 791, page 12645.]

ELECTRIC MOTIVE POWER ON ELEVATED RAILWAYS.*

By WILLIAM NELSON SMITH.

IN making the horse power calculations which follow, I have followed the method given by Mr. Sprague of estimating the work done between each station in foot pounds and dividing by 33,000, getting what are termed "33,000 foot pound units." Ascertaining the number of these required per round trip, by multiplying by the number of stations, and dividing the product by the running time in minutes, the average horse power is obtained.

$$\frac{\text{Foot pounds per station}}{33{,}000} \times \frac{\text{No. of stations}}{\text{running time}} = \text{avg. h.p.}$$

In order to compute the amount of copper necessary, and the size of the power station, the maximum amount of power required at any one time must now be calculated.

On the South Chicago line, the estimate will be made for the 3·41 miles at present under construction.

If 25 miles per hour be the maximum speed, the energy required simply for overcoming the inertia of the train will be

$$\frac{123{,}000 \times 36·6}{64·32} = 2{,}562{,}639 \text{ foot pounds}$$

The stations average 1,760 feet apart, and about 280 feet of this is covered while bringing the train to a stop, leaving 1,450 feet as the traction distance. The resistance to the train has been already seen to be 492 pounds, 492 × 1,450 = 713,400 foot pounds, the work expended in traction.

2,562,639
713,400

Total, 3,276,039 foot pounds, between each station.

3,276,039 ÷ 33,000 = 99·27 33,000 foot pound units.

In one round trip there are 18 stations.

99·27 × 18 = 1,786 horse power per round trip, expressed in 33,000 foot pound units.

If the trains be run by steam, they will consist of five cars each, probably, and during the busy hours they will be run at three minute intervals. The time for a round trip will be not less than 32 minutes. There will thus be about ten trains on at one time, or fifty cars in all. The electrical trains will be of three cars each, and there will be about 17 of them. Or, since the motor cars will not hold as many passengers as the others, call the maximum number of trains that will be running at once, 18.

$$\frac{99·27 \times 18}{32} = 55·8 \text{ horse power, the average rate of expenditure, per train.}$$

55·8 × 18 = 1,004 horse power, the maximum expenditure at any one time.

This is mechanical horse power, estimated at the axles.

It will be remembered that the efficiency of the system was taken at 55 per cent. from steam engine to car axle.

1,004 ÷ 55 = 1,826 horse power, at the power generating station.

But it will be remembered that, by the use of electrical braking, a portion of the energy of stopping may be restored to the system in the form of current. It may be assumed that a train will be stopped in the same interval of space as is now required for a steam train, or about 290 feet. It will be remembered that traction assists in the work of retardation, and that it must therefore be subtracted from the total work done in computing the amount of power which the train will make available for external purposes, in stopping. As before, the work done in changing the kinetic energy of the train is

2,562,639 foot pounds.

The work of traction, 290 × 492 = 142,680 foot pounds.
The difference is 2,419,959 foot pounds.

In constructing the motor it has been assumed that it will be governed by the field only between half speed and full speed, it being necessary to introduce resistance below half speed. Hence, since at half speed the train has given up three-fourths of its kinetic energy, there will be available three-fourths of the energy of stopping to be turned into electrical energy, friction, and so forth.

0·75 × 2,419,959 = 1,814,967 foot pounds.

Dividing by 33,000, we obtain 55 horse power, expressed in 33,000 foot pound units.

There being thirteen stops per round trip, we have, in 33,000 foot pound units, 990 horse power available, per train. As this is distributed over the 32 minutes of running time, we have

$$\frac{990}{32} = 30·9 \text{ horse power per train; and as there are}$$

eighteen trains, 30·9 × 18 = 556·2 horse power which is capable of being partly reconverted into electrical energy, and of application to the motors of other trains. The total efficiency of this conversion, including friction, fall of potential on line, etc., has been estimated by Mr. Sprague at about 60 per cent.

556·2 × 0·60 = 333·7 horse power saved, which may be deducted from that computed as the total necessary supply.

* A thesis read at Sibley College, Cornell University, May, 1890.

1,004 − 334 = 670 horse power, to be supplied at the generating station. Of this about 1,100 horse power will be electrical energy, at the dynamos.

Now as to the copper required.

Mr. Sprague has enunciated a formula, which he has found to answer very well for such determinations. The formula is empirical, and is as follows:

$$cm = \frac{15{,}666\, n\, l}{4\, E\, v\, \varphi}$$

The circular mils are represented by cm, n is the number of horse power, l the length of the line in feet, E the potential at the motor, v the fall in potential, and φ the commercial efficiency of the motor, the power station being situated at the middle of the line.

Allowing a drop of 60 volts and a motor efficiency of 70 per cent., the length of the line being 18,000 feet, and the number of horse power 1,200,

$$cm = \frac{15{,}666 \times 1200 \times 18{,}000}{4 \times 600 \times 60 \times ·70} = 3{,}357{,}000$$

But using the three-wire system will quarter the amount, giving 839,250 circular mils as the aggregate cross section for each conductor. This is the equivalent of four No. 0000 B. & S. wires.

The chief engineer of the West Chicago road was not able to give definite information as to the time required to make a trip, but he gave as the maximum and average speeds about the same as they were to be on the South Chicago road. The running schedule will be assumed as about proportional to the length of the road, which is about five and a half miles. The station intervals are about the same as on the South Chicago road. The total number will be assumed as 36. If the time required to traverse the length of the two roads are proportional to their lengths, the time required to run five and a half miles will be about twenty-five minutes. We may assume fifty-two minutes as the time for a round trip.

Since the speeds and station intervals are practically the same, there will be the same amount of power expended between each station.

The number of three-car trains running at any one time will, according to the proportionality assumed, be about 30

$$\frac{99·27 \times 36 \times 30}{52} = 2{,}061 \text{ horse power, the power demanded by the trains.}$$

$$\frac{55 \times 36 \times 30 \times 0·60}{52} = 686 \text{ horse power, the power actually returned to the system by the stopping of trains.}$$

2061−636 = 1,375 horse power, the actual horse power which the trains demand of the station. The efficiency being 55 per cent., there will be required an engine capacity of 2,500 horse power. The electrical horse power transmitted will be about 2,250.

Applying the formula for a three-wire system,

$$cm = \frac{15{,}666\, n\, l}{4 \times 4\, E\, v\, \varphi}$$

$$= \frac{15{,}666 \times 2{,}250 \times 29{,}040}{4 \times 4 \times 600 \times 60 \times ·70}$$

$$= 2{,}539{,}000$$

This is the equivalent of 12 No. 0000 wires, over each track.

We will now consider the Lake St. road. This is to be 10 miles long when finished. The maximum speed is to be 30 miles per hour; and the stations are, as before, about a third of a mile apart. The schedule time, however, will hardly be over 20 miles an hour, and as it is not likely, in the writer's opinion, that a round trip will be made in less than an hour, that time will be assumed in the calculations.

The assumption will also be made that in order to stop, a train will have to begin slackening 350 feet from the station. This is only a guess, but considering the greater speed of the train, it may not be far out of the way. The weight of the train will be taken at 65 tons. Energy required to overcome inertia,

$$\frac{130{,}000 \times 44}{64·32} = 3{,}912{,}928 \text{ foot pounds}$$

Energy required for traction:
Train resistance, 65 × 8 = 520 pounds
1,760 − 350 = 1410 feet.
1,410 × 520 = 733,200 foot pounds.
Total energy required, in 33,000 foot pound units.

$$\frac{3{,}912{,}928 + 733{,}200}{33{,}000} = 140·8 \text{ horse power for each station interval.}$$

The maximum number of three-car trains would be 35 at any one time.

Time of round trip, 60 minutes (approx.)
Total number of stations, 60.

$$\frac{140·8 \times 60 \times 35}{60} = 492·8 \text{ horse power demanded by the motors.}$$

As before, three-fourths of the energy of stopping will be considered as available for conversion.

Energy given out by slackening train is 3,912,928 foot pounds.

From this is subtracted that absorbed in traction, 350 × 520 = 182,000 foot pounds.

Difference, 3 730,928 foot pounds.

Dividing by 33,000, we obtain 113·06 units.

113·06 × 0·75 = 84·7 horse power in 33,000 foot pound units, which is the power available for conversion at each stoppage.

$$\frac{84·7 \times 60 \times 35 \times 0·60}{60} = 1{,}779 \text{ horse power which is given back to the line.}$$

$$\frac{4928 - 1779}{0·55} = 5{,}725 \text{ horse power, the necessary engine capacity at the power station.}$$

About 90 per cent. of this will be electrical horse power, or about 5,150 horse power.

The calculation of the copper is as before.

It would probably be preferable, however, to have two power stations, five miles apart, as this will again quarter the cost of the copper and diminish the liability to break down, to some extent. The amount of copper varies inversely as the square of the number of stations.

The formula, after substitution, will be

$$cm = \frac{15{,}666 \times 5{,}150 \times 52{,}800}{4 \times 4 \times 4 \times 600 \times 60 \times ·70}$$

2,642,000 equivalent to 16 No. 000 wires.

As an excellent type of power station of this character, the new Brooklyn Edison Central Station is referred to, which embodies all the best features of modern practice. The only advance that the writer would suggest would be the adoption of multipolar dynamos and triple expansion engines.

The design of the dynamos would be, in the main, a repetition of the motor problem, as far as the fundamental principles are concerned. There being available all the needed space, no restrictions would be laid as to size or shape. In the writer's opinion that form is preferable which has a ring-shaped field with pole pieces projecting inward toward the armature, which rotates at its center. The Westinghouse dynamo is a fair example of this type. There are several methods of indicating the proper cylinder areas for a triple expansion engine. The writer undertook, by one of the simplest methods, indicated in Whitham's "Steam Engine Design," page 156, to ascertain the cylinder diameters of a triple expansion engine of 500 horse power, running at 150 revolutions per minute, stroke 30 inches, initial pressure 135 pounds absolute, terminal pressure 8 pounds absolute, vacuum of 4 pounds absolute. By drawing the theoretical card and making allowances for drop, compression, etc., and then dividing it into three equal areas, and ascertaining the mean effective pressure of each diagram, the cylinder areas obtained by the formula given by Whitham were 131, 497, and 1,312 square inches, respectively, giving diameters as 13, 25, and 41 inches. This is on the supposition that each cylinder is to do one-third the work. There are other considerations also, such as the equalization of the three initial pressures, and the proper range of temperature for each cylinder. These dimensions might have to be modified somewhat, for the above reasons; but they present a fair idea of the size of the engine.

In a triple expansion engine the designs for which were brought over from France by Mr. Edison, last summer, the low pressure cylinder is divided, and cushioning for each part is obtained by placing the high pressure cylinder in tandem with one and the intermediate with the other.

Mr. Ball, of Erie, Pennsylvania, is now building engines on this plan.

As to the line, wiring, and so forth: the trolley wire will be held in clamps, and thoroughly insulated by vulcanite or some of the preparations now in common use. The wire would be thoroughly protected by using a shield of thin wrought iron plate, bent so as to form a semi-cylinder about the upper side of the wire, and thereby obviate any difficulties arising from accidental crossing of falling telegraph or telephone wires, at the same time forming a good protection from the weather. In view of the high potential, this matter of protection from rain and snow ought to be taken into account. These shields would be supported by central posts with cross arms extending over each track, at intervals corresponding to the piers supporting the road. The weight of this contrivance I have estimated at about 50 pounds per running foot of double track railway, including the posts.

Estimates have been furnished by Henry R. Worthington firm of New York as to pumps and condensers, which may be of interest.

For the South Side plant, of 1,500 horse power, a 10 and 6 × 10 duplex pump, costing $430, and Worthington independent condenser, costing $3,000. For West Chicago plant, of 3,000 horse power, a 14 and 18½ × 10 pump, costing $660, and condenser $5,000.

For a *single* plant of 6,500 horse power, pump 20 and 12 × 10, costing $1,000, and condenser, $9,000.

For two plants, aggregating 6,500 horse power, as is actually considered, these figures might be slightly increased, but the cost would come easily within $2 per horse power.

There are many other points of interest in all portions of such a system, which would require more or less modifications in order to suit the needs of the system; and a treatise of almost indefinite length might be written were all of them considered. I have only attempted to cover a few main points, those of the greatest importance. We can now proceed to inquire as to the cost of an electrical system as compared with steam.

COMPARATIVE COSTS.

Having determined the demands of each system, it is now possible to make estimates as to the cost of equipment. The South Chicago line requires about 1,200 horse power. To allow for emergencies, we will call it 1,500 horse power.

Babcock & Wilcox boilers will, for a plant of this size, cost about $20 per horse power.

Triple expansion engines of 500 horse power will, according to an estimate given by Mr. F. H. Ball, cost about $14 per horse power.

The writer was informed by Mr. Starkey, of the Sprague company, that $40 per horse power might be allowed for large dynamos. For the size here considered, that item might be considerably reduced, but we will let it stand. The total estimate is therefore $74 per horse power. Including condensers, pumps, feed water heaters, piping, copper, and so forth, the total cost probably will come up to $85 per horse power.

The copper required will be 144,030 feet of No. 0000 wire, weighing 92,090 pounds. At 17½ cents per pound, this will cost $16,115.

This road was to run 18 electrical three-car trains simultaneously. For relays, and so forth, the estimate will be made at 22 trains. This will mean 22 motor cars and 44 ordinary passenger cars.

For want of more definite information, I will hazard

the cost of the motor cars at $10,000 each; the cars cost about $3,500 each.

Then 22 motor cars will cost............$220,000
and 44 ordinary cars................... 154,000

Cost of electrical rolling stock....... $374,000
The station building could probably be erected for........................ $60,000

For steam locomotion there would be about 11 steam trains in service at any one time, each of 5 cars, which will be taken as the length of a steam train, as in New York they are frequently of that size.

We should reckon on about 15 locomotives and say 70 cars, as the steam equipment.

Steam locomotives, of the size required, cost about $5,000 each.

15 locomotives would cost.............. $75,000
70 cars " 245,000

Total cost of steam plant.............. $320,000

For the electrical plant:

22 locomotives:
44 cars:
Rolling stock.......................... $374,000
Line copper 16,115
Power plant............................ 127,500
Station building....................... 60,000

$578,000

To this must be added the cost of the iron needed for the overhead work, at 50 pounds per running foot of double track, and at 3·65 cents per pound.................................. $33,000

$611,000

The items for the West Chicago system are reckoned up in the same way.

Steam plant:
20 locomotives at $5,000............... $100,000
100 cars at $3,500 350,000

$450,000

Electrical plant:
33 locomotives at $10,000.............. $330,000
66 cars at $3,500...................... 231,000

Cost of rolling stock.................. $561,000
697,061 feet of No. 0000 copper, weighs 445,650 pounds, cost................... 78,500
3,000 horse power at $85............... 255,000
Iron overhead work..................... 53,000
Building accessories, etc.............. 90,000

Total cost............................. $1,037,000

In this plant, 500 horse power was added for contingencies.

The following are the estimates for the Lake Street road, allowing for 6,500 horse power at the station. Allowance is made for 20 steam trains, or 35 electrical trains as a maximum:

Steam plant:
25 locomotives at $5 000............... $125,000
125 cars at $3,500 437,500

Cost of steam equipment................ $562,500

Electrical plant:
40 electric locomotives at $10,000..... $400,000
75 cars at $3,500 262,500

Cost of rolling stock $662,500
1,689,600 feet of No. 000 wire weighs 856,750 lb., cost..................... $150,000
6,500 horse power at $85 552,500
Overhead iron construction............. 96,000
2 buildings, etc....................... 180,000

Total first cost....................... $1,641,000
562,500

Excess over steam plant................ $1,078,500

Now let us see whether enough can be saved by the use of electricity to pay the interest on this excess of first cost. This will be worked out only for the Lake Street road, which requires the largest outlay of the three.

We have seen that the average expenditure of power, on this line, is about 140·8 units of 33,000 foot pounds each, for every station passed, assuming a three-car electrical train weighing 65 tons.

For the steam trains, which weigh, including a 22 ton engine and five 20 ton cars, 122 tons in the aggregate, we must make a new determination of the power expenditure.

In order to bring our train up to a speed of 30 miles per hour, there must be expended, in overcoming inertia,

$$\frac{244{,}000 \times 44}{64 \cdot 32} = 7{,}177{,}100 \text{ foot pounds.}$$

The resistance, which is $122 \times 8 = 976$ pounds, must be overcome through 1,410 feet, making the energy expended in traction

$$1410 \times 976 = 1{,}376{,}160 \text{ foot pounds.}$$

The total is 8,553,260 foot pounds.

$$\frac{3{,}553{,}260}{33{,}000} = 259 \cdot 2 \text{ units of } 33{,}000 \text{ foot pounds, per train}$$

per station.

There being 60 stops, and the running time having been assumed at not less than 60 minutes.

$$\frac{259 \cdot 2 \times 60}{60} = 259 \cdot 2 \text{ horse power the average expenditure}$$

per train per round trip. On the Sixth Avenue line of the Manhattan Railway the maximum number of trains dispatched from both termini, in one hour, is 68, while the average for the 24 hours is about 38.

On the Lake Street road, we have assumed the maximum as the equivalent, in steam trains, of twenty per hour.

If we assume the relation of average to maximum as the same for the two railroads, we obtain about 11 as the average number of steam trains per hour on the Lake Street road. The total number of trains for the 24 hours would therefore be $24 \times 11 = 264$ trains of 5 cars each. Assuming the coal expenditure at 6 lb. per hour, we have, since the time of a round trip is just one hour,

$$259 \cdot 2 \times 6 = 1{,}555 \cdot 2 \text{ lb. coal per round trip.}$$

$$1{,}555 \cdot 2 \times 264 = 410{,}572 \cdot 8 \text{ lb. coal consumed in 24 hours.}$$

This is, in round numbers, 205·3 tons.

At $5 a ton, this will cost $1,026 50.

Let us now determine the coal consumption of our electrical system for 24 hours. As we have seen before, the number of 33,000 foot pound units required, by each electrical train, per station passed, was 140·8, while the amount available for recovery was 84·7 units, of which 60 per cent. was actually saved, or 50·8 units. The net consumption per train per station is therefore the difference, or 90 units.

$$\frac{90 \times 60}{60} = 90 \text{ horse power, the average rate of expenditure per train.}$$

If the ratio of average to maximum number of trains, per hour, is as 38 to 68, having assumed 35 trains as the maximum, we will obtain 19 per hour as the average. The total number of trains in 24 hours will then be $19 \times 24 = 456$.

If the efficiency of the system be 55 per cent., $90 \div 0 \cdot 55 = 163 \cdot 6$, the average horse power expended for each train at the central station. The running time being one hour; there will be used for each round trip,

$$163 \cdot 6 \times 2 = 327 \cdot 2 \text{ lb. coal.}$$

$$\frac{327 \cdot 2 \times 456}{2{,}000} = 74 \cdot 6 \text{ tons coal, consumed in 24 hours.}$$

$$74 \cdot 6 \times \$3 = \$223 \ 80.$$

24 hours' operation of steam plant costs........................... $1,026 50
24 hours' operation of electrical plant costs........................... 223 80

Difference............................. $802 70

If, during 365 days, there be saved $802 70 per day, we will have, at the end of a year, $292,985 saved in the matter of fuel.

The difference in first cost was $1,078,500.

The deduction is, therefore, that an electrical plant will pay for its extra first cost in less than four years, and this, too, with an efficiency of only 55 per cent.

Even if it cost twice as much as has been mathematically estimated, to run the electrical plant, or $453 60 per day, there would still be a daily saving of $572 90, amounting at the end of the year to $209,100.

This is on a coal basis alone. As to employes, there would in all probability be a slight increase in their number, which will to a small extent offset the decrease in fuel expense. But it does not seem as if the necessary increase in the number of employes would very greatly diminish the remarkable rate of interest on increased first cost, which would follow the use of electrical motive power.

For smaller plants, the difference might not be so markedly in favor of electricity as on a large scale, but so many are the advantages it offers in any case, that it would undoubtedly be worth while to adopt it, even if it took several times four years to pay off its increased indebtedness.

A tabulation of costs, etc., is herewith presented as a summary of what precedes.

RECAPITULATION.

Steam.

Line.	Locomotives.	Cars.	Cost of Rolling Stock.
South Chicago...	15	80	$320.000
West Chicago ..	20	100	350,000
Lake Stre t......	25	125	562,000

Electricity.

Locomotives.	Cars.	Cost of rolling stock.	Pounds copper.	Cost of copper.	Cost of buildings, plant, and overhead cond.	Total cost.
S. C...... ..22	44	$374,000	144,030	$16,115	$220,500	$611,000
W. C.......33	66	501,000	445,650	78,500	398,000	1,037,000
L. S.......40	75	662,500	856,750	150,000	828,500	1,641,000

DIFFERENCE IN FIRST COST.

S. C. Railway.......................... $291,000
W. C. " 687,000
L. S. " 1,078,000

The saving in fuel for the Lake Street road has been calculated at about $800 per day, or nearly $293,000 annually. An electrical system would thus pay for its extra first cost in less than four years.

These general results seem to me to be not at all unreasonable.

In closing, I desire again to express my gratitude to all the engineers to whom I am indebted, for their uniform kindness, courtesy and encouragement. While the general adoption of the electric motor on the railway may yet be a long way off, I have accomplished my purpose if I have shown that the obstacles to be encountered are by no means beyond the capabilities of electrical engineers.

A PRACTICAL ELECTRIC RAILWAY CONDUIT.

By STEPHEN D. FIELD.

THE subject of conduits for electrical railroads has occupied considerable space in this journal of late, and is one which is seemingly beset with many difficulties, judging from the elaborate constructions described, and the poor success attending their installation. The various details of conduit construction have been thoroughly worked out by cable railway engineers, and it only remains for the electrical engineer to supply the necessary insulating conductors and contacts to secure a sure and lasting installation for electric traction.

I have endeavored in the accompanying illustrations to point out one design which I think will answer the purpose.

The two factors most required in electrical conduits for railroads are perfect insulation and accessibility of parts. The conduit shown has fittings so designed that all electrical attachments can be removed and renewed without disturbing the integrity of the conduit. The insulation may be so high that leakage will be inappreciable in any kind of weather.

The conduit frame, A, is made of cast iron, capped with steel at the slot. Insulation is provided by means of the well known Brooks insulator, B, set at intervals

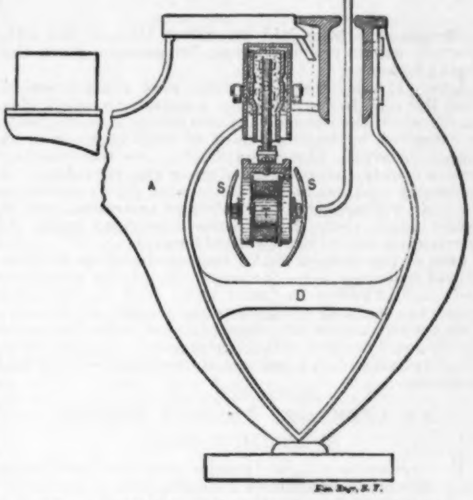


FIG. 1.—FIELD'S ELECTRIC RAILWAY CONDUIT.

of ten feet along the line of the conduit. The working conductor, F, is made in sections of twenty foot lengths, arranged to "break joints."

Contact with the working conductor is obtained by what is termed a "magnetic trolley," T, which consists of two soft iron wheels fixed rigidly on a core which turns within a fixed coil, C. A current of 0·1 ampere passing through the coil causes the trolley wheels to adhere firmly to the iron working conductor. A spring is provided, just sufficient in strength to keep the trolley lightly against the conductor when no current is passing through the coil.

Immediately above each insulator a trap is provided through which the conduit may be cleaned and the insulators changed.

A brace, D, passes from side to side of the conduit at about one-third of its height. This secures rigidity of construction and allows of a lighter and less expensive yoke than is used in cable construction where no such device is permissible.

The switching is accomplished on the working conductor in precisely the same manner as on the surface track.

The outer wall of the conduit may be used as one of the rails by allowing the flanges of the car wheels to run in the slot.

The lower portion of the conduit is so shaped as to provide adequate drainage, and it will be seen that water entering the slot falls clear of the working conductor and trolley. An insulating shield, S, encircles all the exposed metallic parts of the trolley, thus guarding against accidental contacts. Connection between the trolley and car is obtained by a hollow arm

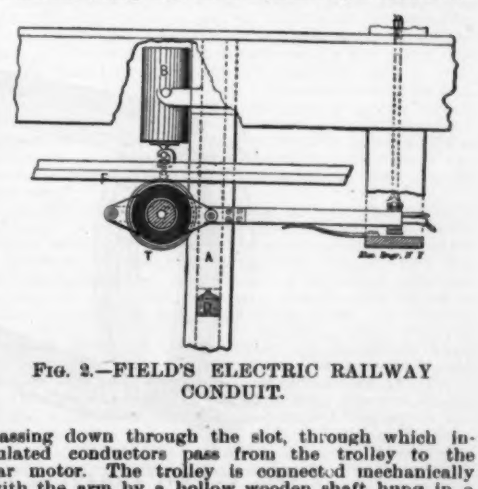


FIG. 2.—FIELD'S ELECTRIC RAILWAY CONDUIT.

passing down through the slot, through which insulated conductors pass from the trolley to the car motor. The trolley is connected mechanically with the arm by a hollow wooden shaft hung in a gimbal.

The working conductor is of such a shape that it can be passed through the street slot and removed when necessary through the same opening. The joints in this conductor are bridged by strips or wires riveted to their adjacent ends, while current is supplied from an insulated trunk line laid parallel to the conduit, the working conductors being laid down in sections of five hundred feet and attached to the trunk line by branches containing cutouts. As the trolley runs on the under side of the working conductor, it is obvious

that it always finds a clean surface to travel on. No dirt from the street can find lodgment there. Magnetic adhesion provides an intimate contact, with scarcely any weight and little resistance to progressive rotation.

In any cold climate the conduit may be kept open by means of a pipe laid on either side of the slot, through which hot brine can be pumped from the engine house.

A very few degrees of artificial heat communicated from the pipe to the conduit is required to effect this result, while the efficiency of this device may be greatly extended by having relays of heating stations at proper intervals along the track. As this heating system is only in operation during the prevalence of extremely cold weather, it is probable that a few days per year will cover its total time of operation, and it would seem that the expense attendant upon its operation is too trivial for consideration.

I am of the opinion that a road equipped as indicated will be found to be far more reliable in operation and unobstructive in installation than is the case where the working conductors are carried in the air. This system can be introduced for less than the cable system, and worked with greater speed, freedom from interruption and at a less cost of operation.—*Electrical Engineer.*

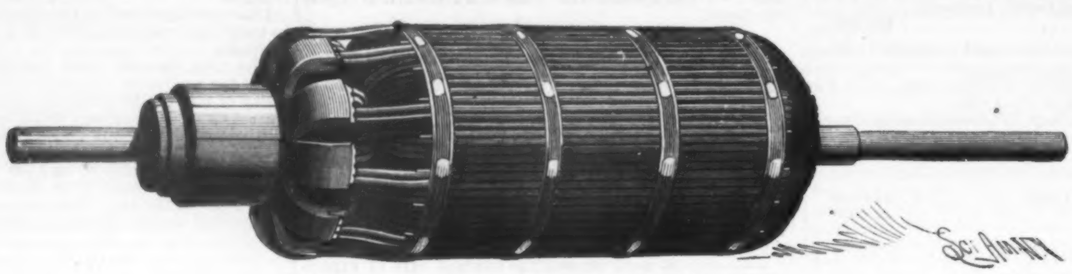


FIG. 1.—PERSPECTIVE VIEW OF ARMATURE.

AN EFFICIENT PLATING DYNAMO.

By GEO. M. HOPKINS.

To convert the 8 light dynamo described in SUPPLEMENT 600 into a machine for electroplating, it is necessary to replace the armature with one wound with very coarse wire and to provide a switch which will connect up the sections of the field magnet wire in parallel or in series as may be required.

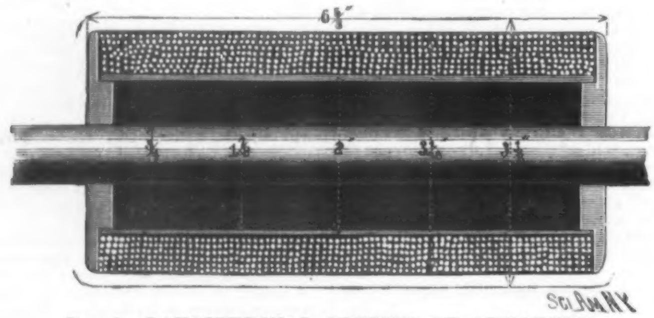


FIG. 2.—LONGITUDINAL SECTION OF ARMATURE.

The armature for plating has but a single layer of wire with two convolutions to each layer. To facilitate winding, two parallel wires, No. 10 B. and S. gauge, are used in each coil instead of using a single larger wire. Fig. 1 shows the armature complete, and Fig. 2 shows the armature core in section with the dimensions marked on.

It consists of an iron spool filled with No. 18 or No. 20 very soft iron wire either rusted or varnished to prevent Foucault currents.

The heads of the spool are provided with twenty radial slots in which are inserted the small wedges, *a*, separating the coils of the armature. The wires forming the coils are each about twenty inches long. The winding is according to the Froelich method. Coil 1 (consisting of two parallel wires as described) is placed entirely upon one side of a diametrical line of the armature and begins and ends upon the same side of the armature. Coil 2 is placed on the opposite side of the same diametrical line, and begins and ends on the opposite side of the armature. Coil 3 begins on the same side of the armature as coil 1, adjoining coil 2 on that side, but leaving a space between it and coil 1 on the opposite side of the armature for coil 4, which is to be started and finished on the same side of the armature as coil 2. Coil 4 will adjoin coil 3 on the side of the armature opposite that on which the coil is started and finished. The armature is proceeded with in this manner until all the spaces are filled up and the coils are all in place with their ends projecting as shown.

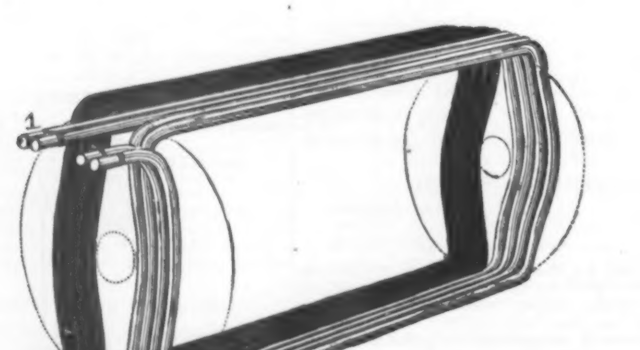


FIG. 4.—TWO ARMATURE COILS SEPARATE FROM CORE.

There are ten coils, and the same number of bars in the commutator cylinder. Each commutator bar receives the end of one coil and the beginning of the next, so that the coil is closed as in the case of the Siemens armature described in SUPPLEMENT 600.

If desired the coil may be wound according to the Siemens (or Heffner-Altneck) method, provided a commutator cylinder has an odd number of bars and the armature an odd number of coils. The Siemens method thus modified is, in fact, the Edison winding.

The only material difference between the commutator cylinder here shown and that described in connection with the 8 light dynamo in SUPPLEMENT 600 is in the provision for heavy connections between the bars and the coils. In the present case each bar has formed integrally with it a radial arm which is bent toward the armature core, and slots, R, are made in the end to receive the terminals of the coils, which are soldered in the slots. The arrangement of the terminals of the coils is the same as in the Siemens armature, *i. e.*, each commutator bar receives the end of one coil and the beginning of the next.

The commutator cylinder is built up on a flanged sleeve, M, fitted to the armature shaft. The flange of the sleeve is grooved in the side to receive the lugs projecting from the commutator bars, P. A tube, O, of insulating material, such as hard rubber or vulcanized fiber, is slipped over the sleeve, M, and the groove in the flange of the sleeve is lined with insulating material. A countersunk nut, N, is screwed on the end of the sleeve, M. Between the nut and the beveled ends of the commutator bars is placed an insulating washer, Q. The bars, P, are separated from each other by mica.

The commutator brushes used on the 8 light dynamo will answer for this armature, but wider ones would be preferable.

The field magnet of the 8 light dynamo above referred to is used in connection with the armature here shown and described, but a switch is required by means of which the current may be sent through all the coils in series, or all in parallel, or with any intermediate arrangement, so that the current can be controlled at will.

The switch is made in cylindrical form with metallic plates and connections as shown in Fig. 7, in which the surface of the cylinder is spread out flat to permit of easy explanation.

The cylinder forming the body of the switch is of wood. It is provided with journals which revolve in bearings in a wooden frame attached to the top of the field magnet. On the ends of the wooden cylinder are mounted copper rings, C D, which are pressed by springs, A B, connected with the commutator brushes as shown in Fig. 6. Between the rings, C D, are arranged four series of plates which may be brought into contact with the series, *a b*, of springs secured to the wooden switch frame and connected with the terminals of the separate coils of the field magnet—the terminals 1, 2, 3, 4, 5, 6, 7, 8, of one-half of the field magnet being connect-

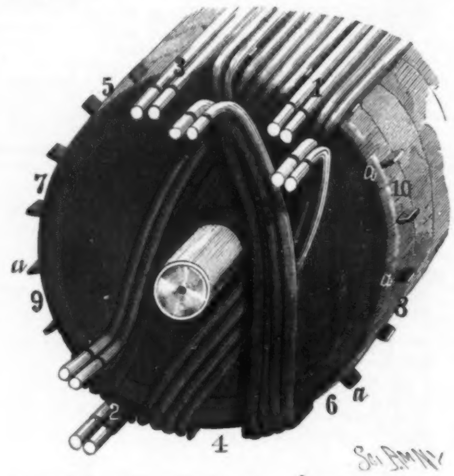


FIG. 3.—COMMUTATOR END OF ARMATURE.

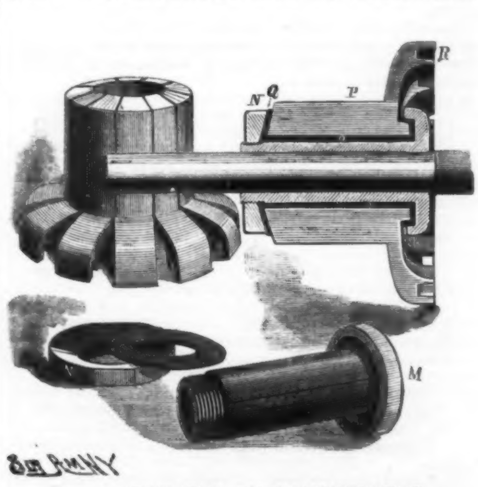


FIG. 5.—DETAILS OF COMMUTATOR.

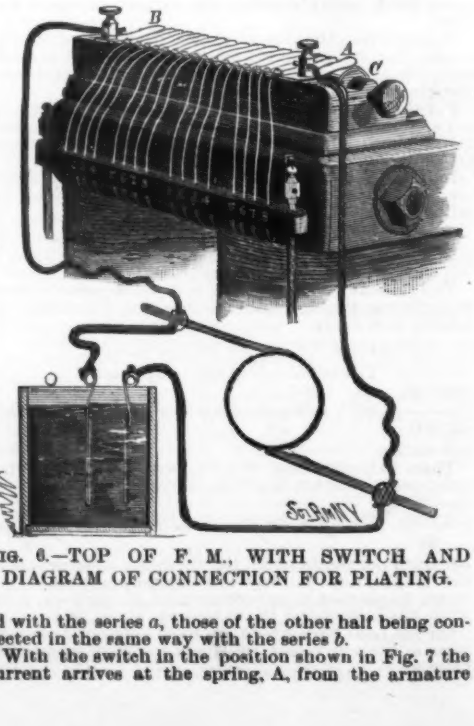


FIG. 6.—TOP OF F. M., WITH SWITCH AND DIAGRAM OF CONNECTION FOR PLATING.

ed with the series *a*, those of the other half being connected in the same way with the series *b*.

With the switch in the position shown in Fig. 7 the current arrives at the spring, A, from the armature

passes to the ring, C thence to the plate, c, and through the connecting wire to the plate, c', thus causing the current to pass down the field magnet wires, 5, 6, 7, 8, of each series. It returns to the switch through wires, 1, 2, 3, 4, of each series to the plates, d, d', which are connected electrically as shown.

From the plates, d d', the current flows to the ring, D, and spring, B, thence back to the armature. By this arrangement all the coils of the field magnet are thrown in parallel. By turning the switch so as to bring the springs in contact with the plates, E, F, G, the arrangement is such that the current flows through four coils in parallel and two in series. By bringing the plates, H, I, J, K, L, into contact with the springs the current passes through two coils in parallel and four in series, and when the switch is turned so as to bring the plates, F, G, H, etc., in contact, the current passes through all the coils in series, i. e., the current passes through the winding of the field magnet as it would through an ordinary electro-magnet, i. e., it passes

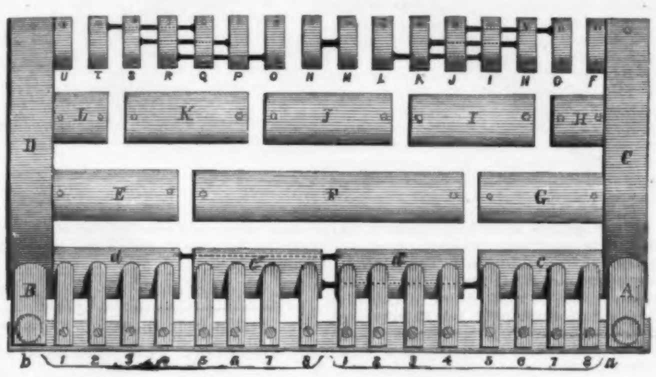


FIG. 7.—DIAGRAM OF SWITCH.

from plate, F, through spring, 8, and one coil of the magnet to plate, J, thence by the cross connection to plate, G, through spring, 7, and another coil of the magnet to plate, K, and so on.

By means of this switch the current may be adapted to electrotyping or brass, nickel, silver or gold plating. At 2,500 revolutions per minute, with field magnet in shunt, with current split, running down both arms of the magnet in parallel as first described, the machine yields a current of 55 amperes with an E. M. F. of 5 volts. The current may be varied from 50 to 85 amperes with an E. M. F. of from 2½ to 5 volts and upward.

THE MAGNETIC TELEGRAPH—DR. GREEN'S INTERESTING SPEECH.

THE autumnal meeting of the New York Magnetic Club was held on November 19, at Martinelli's, Fifth Avenue, New York City.

Many distinguished men identified with the telegraph business were present, including Dr. Norvin Green, President of the Western Union Company.

Dr. Green, in his after-dinner speech, said: I want to congratulate your association upon the intelligence of its members, and the telegraph fraternity generally upon the high order of intelligence of all its employes, from superintendents and managers down. The telegraph service is an employment that gives opportunity for study, reading and improving the mind, and a telegrapher is generally a well-informed man.

In the management of telegraphs during a little less than forty years, I have seen my operators go to high positions on railroads, to the editorial chair, and to important political and business positions. One of my operators in the old Southwestern Company, who was employed in a humble position in a railroad depot office, became the president of the Louisville and Nashville railway system, and is now the vice-president and general manager. I refer to Milton H. Smith. With the name of Mr. Carnegie you are all familiar.

I want to congratulate you also upon the great advancement in the electrical sciences, the immense growth of the telegraph and other electrical applications. The telegraph was an American invention, and was generally adopted here before it received any favor elsewhere. But at this date more than one-third of all the telegraph mileage of wires and poles and of the number of telegraph offices in the world is in the United States, and we do nearly one-third the business of all the rest of the world put together. Moreover, we are doing better service, and, I believe, take it all in all, cheaper service than is done elsewhere in the world; yet the telegraph is comparatively in its infancy. There still come into the telegraph new kinds of business, and so it grows on. Notwithstanding the active competition we have, the business of the Western Union, which is the principal telegraph company in this country, is constantly growing. Our increase from about 3,250 test offices alone last week was nearly $24,000 over the corresponding week of last year, and that with the opposition extending everywhere, and with the much talked of long distance telephone considerably extended. The telegraphs of the United States would extend some twenty-eight or twenty-nine times around the circumference of the globe in their wire mileage. The Bible prophecy of putting a girdle around the earth has been practically more than realized. A cable across the Pacific Ocean would complete the only gap in the direct girth of its circumference, which is, however, practically completed in telegraph communication.

Within the period of my own life the telegraph and the steam engine have changed the whole character of traffic. I was a grown man, a country doctor, riding around on a pair of pill bags, before there was a telegraph line in existence. At that time there was no man in the United States who claimed to be worth a million dollars. John Jacob Astor and that rich Philadelphian, Stephen Girard, were named by their friends to be worth from $700,000 to $800,000, but nobody in the West believed that possible. In those days, if a man wanted to buy a thousand bales of cotton and have it shipped to Liverpool, he had to write a letter to New Orleans, which by the stage and slow steamboat process took thirteen days, and to get his answer that the cotton was shipped would consume an equal time, or from twenty-six to twenty-eight days after giving the order. Now the cotton is purchased by telegraph, shipped, billed for Liverpool, bill of exchange drawn, and the whole transaction completed in one day. The telegraph, therefore, has made the millionaires, because the business can be done in a day that then required a month. In the ordinary period of one lifetime no man could have built the fortunes that now exist but for the telegraph. It has condensed time; it has annihilated space.

The telegraph has given employment to a great many thousand people, many of whom have made it the nucleus to prepare for higher positions in life. One of the blessings of the telegraph is the employment it gives to women. In the vicissitudes of life, the changes of fortune and the decrees of fate in our larger cities, so many young women are thrown upon their own resources that it is a blessing to find this new field of employment. I have endeavored all my telegraph career to cultivate and foster this employment, and at times have been pained to find some opposition to it among the higher class of operators. Gentlemen, encourage the women; they are not in your way; they do not lessen the wages of operators; they are paid something less, but just as much in proportion to what they do. I had a lady come to me some time ago from away out in Montana, who said she had a letter of introduction to me from a Mrs. B., who had said to her that I was the best friend to women she had ever known. I said, "Please thank Mrs. B., and tell her that when I go to my last resting place I want no better epitaph to mark the spot than that 'He was a friend to a woman.'"

I had a checkered career in life before I entered the telegraph service. I was a cowboy and a plowboy. What I mean by a cowboy is that I drove the cows home to be milked. I was a flat-boat man, a wood chopper, and then got into a country store. I then got a contract to deliver a large amount of cord wood, which I helped to chop, haul and boat, and out of this made the money that paid for my medical education. Now from all this you can guess that I know what it is to earn my bread by the sweat of my brow. I sympathize with all workingmen. They have a right to organize themselves for the betterment of their condition, but they make a mistake when they violate the law. Strikes cannot succeed in this country except by violating the law. Every man has a right to quit work whenever he pleases, but he has no right to stop others from work. That is their right, and while exercising their own rights they must respect the rights of others. Every position in the country is open to your ambition. A boy who is born in the forests, who is bred in a log cabin and cradled in a sugar trough, may become a president of the United States. Millard Fillmore was a foundling, but became president.

Abraham Lincoln was born in a log cabin in a very poor county in Kentucky, was a flat-boat man, a wood chopper and a rail splitter, and then by hard study qualified himself to become a school teacher; afterward the first lawyer in Illinois, and became one of the most famous presidents of the United States, whose name will perhaps be revered longer than that of any president except Washington. While you are telegraphers, don't neglect improving you minds on all subjects. You are the peers of anybody. When I had a dinner given me in London, and as the first toast ordinarily given there is to the reigning sovereign, I said when I came to be called up that I had drunk to their sovereign, because if they must have a sovereign, I thought they had a very deserving and excellent one, but I had drunk to their sovereign chiefly because I was a sovereign myself, one of the sixty-two million in our country, and I was glad to be able to say to the noble earls and lords around me that we had no titles below the rank of sovereign.

Boys, move onward and look upward. Let your motto be "Excelsior." As Daniel Webster said to an audience of young lawyers, "Boys, if you find it crowded down there, come up higher. There is plenty of room."

I am not going to inflict upon you a long speech, and want to conclude with a toast to a friend and your absent guest, General Thomas T. Eckert—a man of great ability and integrity of character, to whom dissemblance or double dealing is unknown. You always know where to find him, and he, by his energy and fidelity, has deservedly placed himself at the head of the telegraph fraternity.

PHOTOGRAPHERS' EYESIGHT.

Does Practical Photographic Work Unduly Try the Eyes; and, if so, What Precautions Can be Taken to Preserve the Eyesight from Unnecessary Strain?—First of all, the sudden transition from a dark room into full daylight should be avoided, for if the eyes are predisposed to weakness, this will help to develop it, and it is, therefore, wise to so arrange the position of the dark room that the operator has to come into a moderately lighted room or partition before the full light of day has to be faced. If from the structural form of the building this is not possible, the photographer should not neglect to put on a pair of medium-tinted (neutral) *pince nez*, or spectacles, the former being best, as they can be dropped after being worn a few minutes, the silk cord round the neck preventing harm coming to them.

If the operator is short or long sighted, the necessary or most comfortable power can be worked on the tinted glass. The great thing to avoid is any severe muscular or optical change. Nature has endowed the healthy eye with a natural automatic diaphragm to contract or enlarge according to the amount of light, but it will in time revolt against a continuation of sudden strains caused by the constant alternative use of the eyes in strong light (such as one oftentimes gets in the studio) and then in the dark room. The absence of this adjustment is iritis.

Fumes and Ventilation.—There is no doubt that the eyes of some people are very much affected by fumes, and it is therefore of great moment that the dark room should be properly ventilated, and as so many places, such as bath rooms, are utilized by amateurs as dark rooms, which only have a window for a ventilator, it follows that if this is blocked up to exclude the light, the vapor of ammonia and kindred volatile chemicals, as well as fumes from paraffin lamps when used, cause the eyes to water and smart.

Weak Sight.—If the eyes have any difficulty in seeing small print, or when retouching, painting, etc., a suitable convex or other glass should be resorted to, and each eye should be tested separately on test types, or, if possible, with a good optometer, so that the focus of the eye may be determined, and the amount of accommodation or natural adjustment shown. The right time to take to glasses may be known when, after reading or working for one or two hours in a reasonably bright artificial light, the smaller types used in reference books, such as brilliant or pearl, cannot be easily read, or the figures in a "Bradshaw" or other time table having small print and figures are difficult to make out.

Over-sightedness (*Hypermetropia*) is often confused with ordinary old or weak sight, but it is quite distinct, for convex glasses improve distant vision as well as near by shortening the focus of the eye to that of normal vision, so that there is not so much muscular effort necessary to accommodate the sight to different distances, and in the majority of cases the same power answers for all purposes, whereas with presbyopic or old sight the distant objects cannot be seen with the reading glasses.

Optometric Tests.—By the optometers constructed on the plan of Dr. Smee, and since improved by various oculists and opticians, normal sight can be verified by the definite numbers down the scale that the letters can be read, and the near and far point of vision shows the focus and amount of accommodation. Generally, it is three and a half to nine when using the standard magnifying lens at the ends of scale, to bring the readings down to a reasonable limit. If the eye is short-sighted, the range is then two to four, two and a half to six, or three to seven, according to the degree of myopia. If hypermetropic, the eye will see from four to fifteen, and even further; and in some cases the near point will be almost normal, while the distant point is near the bottom of the scales (100). This shows an excess of accommodation which, if allowed to be exercised, causes considerable fatigue, whereas with the use of properly selected cover glasses the focus and range of vision is reduced to the normal, and hence the exertion on the muscular power of the eyeglasses.

Weak Sight.—The optometric range for old sight varies from four and a half to ten, or eight to thirty, and with very old people, forty or sixty to eighty or a hundred. With short sight, where the near point of vision (by the unaided eye) is beyond seven inches focus, no serious trouble or difficulty is experienced in reading or working; but if the book or object has to be brought nearer than this, then concave glasses (even if of low power) should be used. It goes without saying that persons who are decidedly short sighted, when once they realize what they lose by not seeing properly, and are well fitted, will use glasses from choice; but I have met people that have lived to past the age of middle life and have never seen clearly beyond a yard or two from their faces, and notwithstanding it was demonstrated what they lost, it required considerable persuasion to get them to take to the use of glasses regularly.

Astigmatism.—A great number of people suffer from this defect of vision, caused by the lens of the eye being elongated in one direction, or not giving equal refraction in all meridians. It is detected by not being able to see radiating lines equally distinct, and is most troublesome when combined with weak or short sight. If no ordinary concave or convex lens gives the required assistance and corrects the defect, cylindrical glasses should be tried, and revolved in front of the eye (or the ordinary glasses worn) until one of the necessary degrees is found to make all the radiating lines equally distinct.

Binocular Vision.—If the eyes are of different focus or have different refractive power, the effort to see an object with both eyes will be considerable, especially when within a distance of fourteen inches; and the consequence is that either one eye by habit ceases to work with any vitality, or else considerable effort is made to see, more especially when tired. If on looking through a stereoscope or binocular glass the objects are blurred or double, extra care should be taken to test the sight, especially if it is previously proved that the instrument is in correct optical center. Sometimes it is impossible to get binocular or stereoscopic vision with instruments on account of the width between the eyes not agreeing with or being suitable to the width between the optical instrument. Hence this matter should not be lost sight of. For instance, I have had on several occasions to fit binoculars to persons only two and a quarter inches between the pupils, and at other times as wide as two and three-quarters; and it will be readily understood that the ordinary width binocular field and opera glasses, and some stereoscopes (without lateral width adjustment), will not satisfactorily answer in either case, and so special instruments have to be made. Besides this, if the two eyes are different in focus, or require correction for astigmatism, stereoscopic effect will not be possible without considerable effort. Therefore I say to all photographers, have your sight tested if in any difficul-

ty or doubt, and get the proper lenses fitted for the particular work you require to do, just in the same way as you select a wide angle or long focus landscape lens, according to the amount of subject or distance of the view you wish to include when photographing.

Magnifying Lenses.—So long as they are used with judgment, there is no doubt they strengthen the visual power of the sight, for watchmakers are rarely troubled with any defect except a little short sightedness; but when using magnifying lenses for retouching or miniatures, care must be taken that they are large enough for both eyes to see comfortably through the lens, and that the focus is not too short for the diameter to produce distortion.

Enough, I trust, has here been touched upon to show that eyesight is distinctly a photographic subject.—*G. R. Baker, in Br. Jour. of Photo.*

[Continued from SUPPLEMENT, No. 792, page 12652.]

THE POWER OF WATER, OR HYDRAULICS SIMPLIFIED.

By G. D. HISCOX.

THE SIPHON.

THIS is one of the oldest devices for transferring water or other liquids to a lower level over a barrier. It was used by the Egyptians, and is pictured on their tombs of a date 1,500 years before the Christian era. It was a favorite toy of Hero of Alexandria. Its greater use is in the drainage of mines and quarries, and for conveying water from springs over elevations that do not admit of economical excavation.

The inverted form, which is not a true siphon, although so named in engineering phrase, has reached giant proportions as a conveyer of water across great valleys in Europe and our Western States.

The fact that all water in its natural condition contains air in mechanical combination, which is liberated by removing the atmospheric pressure, is the only and great drawback to the continuous flow of water through it, up to a height near the atmospheric or vacuum limit of about thirty-three feet.

The conditions of partial vacuum, or negative pressure, or, rather, loss of pressure, commence to liberate the air at a few feet elevation, and increase up to the limit at which the quantity of air breaks the continuity of the stream, when the operation stops, the rarefied air remaining at the apex, unless by some mechanical means it can be withdrawn from the siphon.

When siphons have but small lift, say from 8 to 10 feet, and can be so arranged as to discharge enough lower than the water at the inlet end as to create a strong current, a siphon may run continuously by carrying the liberated air along with the water, but with heights of from 15 to 25 feet the air accumulates in quantity sufficient to cut the stream at the apex of the siphon and stop the flow; often in a few hours, when the apex is short and holds but little air.

We illustrate the essential features of a good siphon, Fig. 19, which is simple, cheap, and easily managed, but requiring frequent removal of the air by closing the cocks at B and C and refilling the chamber at A and the apex of the siphon with water through the plug, D, in the funnel. The chamber at A may be made quite large, to hold the air of a whole day's run.

The top of the pipe, A, should have a reducing socket with a funnel of galvanized sheet iron soldered to it, as shown in the cut, to form a water seal over the plug, for convenience of filling, as well as to insure an air-tight joint at the plug, which, by frequent use, may not be perfectly tight, and here we should say that absolute tightness against leakage in of air is a most essential feature of the successful working of siphons.

We also illustrate, in Fig. 20, an arrangement for replacing the accumulating air in the siphon with water without stopping the flow. In this plan make the apex section at A of a size larger pipe than the other parts of the siphon. This allows the liberated air from the rising leg to separate and float along the upper side of the pipe and exchange with the water from the reservoir, B.

The slower motion of the water along the apex, and the placing of the tee piece very near the point of descent, allows of the separation of the air and prevents its accumulation beyond the outlet at C, and thereby choking the circulation.

The two cocks, C and D, should have water seals as shown to insure against leakage of air into the siphon.

The reservoir, B, and the seals may be made of galvanized sheet iron with soldered joints, and attached by soldering to galvanized pipe couplings. To start the siphon, close the cocks, H and G, open the cocks, C and D, and fill the siphon and reservoir with water to the top of the funnel, D, and also fill funnel, C, as a seal. Close the cock, D, and open the cocks, G and H, when the water will flow with a velocity due to the difference of water level at the ends, less the friction of pipe and fittings.

When the chamber at B has filled with air, which may be known by rapping on it with the knuckles, close cock, C, open D, and fill with water, closing D first, and open C. After a few trials a constant siphon will become a time keeper, so that the filling of the chamber may be made at stated intervals.

In regard to the sizes, for a 2 inch siphon the cocks, C and D, may be ¾ inch, and the chamber from 1 to 2 cubic feet, according to height of siphon.

A siphon arranged as illustrated in Fig. 21 is a most convenient one, where the apex is at considerable distance from the water supply; and for quarries, where the water drainage is limited and taken from sumps, which are exhausted by a short run of the siphon.

This is essentially like Fig. 19, with the addition of a common plumber's force pump at E, connected to the siphon behind the inlet cock, G, with a cock in its force pipe, F; or, if the stuffing box of the pump is air tight, no cock will be needed at F. A small air cock in the funnel at D completes the arrangement ready for operating.

By closing cocks, G and H, and opening the air cock in the funnel at A, the whole siphon may be easily filled by the pump at E, also filling the funnel full. The air cock at D should be closed first, to keep it sealed by the water in the funnel. The cocks, G and H, are then to be opened and the cock, F, closed. The siphon will then flow until the chamber, A, and part of the horizontal apex pipe becomes filled with air; when the operation of filling may be repeated. There is no special limit to the capacity of the air chamber, which may be made of a larger pipe than the siphon, and extended at a small angle sidewise to give capacity for holding air without increasing the total elevation of the water head in the siphon. The air cock at D should never exceed an elevation of 32 feet above the cock at G.

There is another way of starting and keeping up the flow of a siphon by an air pump attached directly to the apex with a cock in the position of the air cock at D, Fig. 21. The operation of this plan can be made with a plain siphon, without cocks, at H and G, and the pump used only to pump out the air when required. The starting of the siphon requiring no manipulation of terminal cocks, nor traversing over the distance of a long siphon. The only specialty is a good air pump.

We do not recommend the use of cast iron pipe for siphons, the difficulty of keeping it absolutely air tight becoming an expensive item in its maintenance. Wrought iron black or galvanized pipe, with cast iron screw fittings, tarred or galvanized, make the only reliable outfit for siphonage. There is probably no limit to the size of a siphon pipe, within ordinary engineering requirements, with adequate facilities for removing the air.

THE HYDRAULIC OR WATER RAM.

The principle of the water ram may be briefly stated to be found in the power of impact of a column of water, when its motion is instantly arrested by the closing of a waste valve, and may be compared with the power of a blow from a hammer upon an anvil, which will crush a piece of metal that would require the static weight of thousands of such hammers if applied without the power of motion.

The relative conditions of the head of water that can be utilized, its quantity, and the height of required elevation, are the principal factors for determining the quantity of water, apart from the friction of the water in long pipes, that can be utilized from the flow of a spring or stream, with the best proportioned apparatus. The number of strokes of the valve per minute and the weight of the valve is a matter of regulation for the utmost power of any given size ram.

Where the water supply is limited, as from springs, the utmost efficiency is required, and a possibility of 85 per cent. in useful effect has been and may be obtained by the best adjustment of flow and discharge in improved rams.

The ordinary efficiency varies from 50 to 67 per cent.

The useful effect may be readily ascertained by measuring the waste valve flow in gallons per minute, also the discharge in gallons per minute; the height of flow

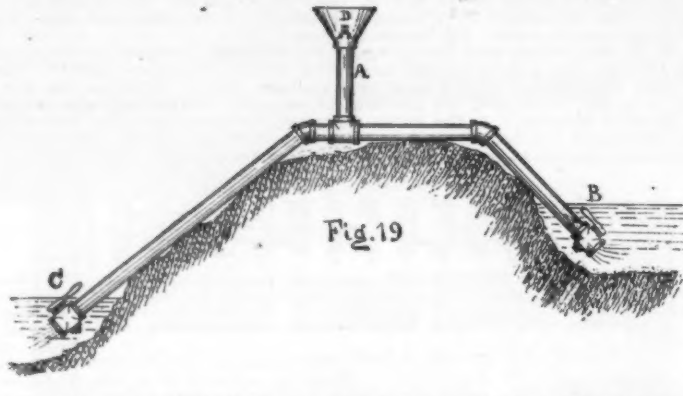


Fig. 19

or feed pipe, and the height of the point of discharge, above the waste valve of the ram. Then the equation becomes:

$$\frac{\text{Height of discharge}}{\text{Height of feed head}} \times \frac{\text{quantity discharged}}{\text{quantity wasted}} =$$

the useful effect. This, when abbreviated to formula, is

$$\frac{h}{h'} \times \frac{q}{q'} = \text{coefficient of ram; in which}$$

h = height of discharge.
h' = height of feed head.

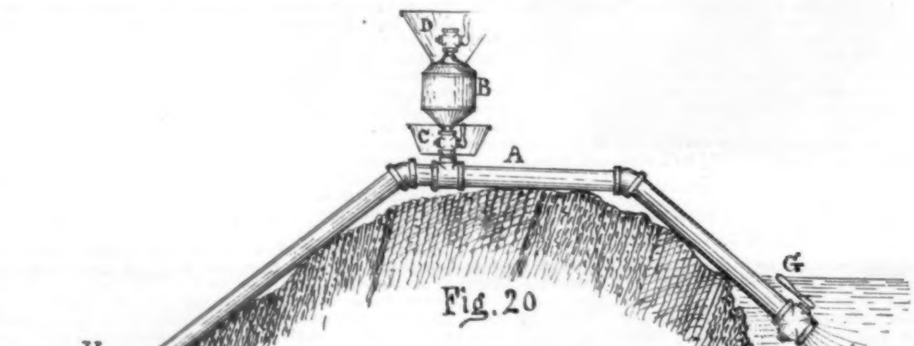


Fig. 20

q = quantity of discharge in gallons per minute.
q' = quantity of waste in gallons per minute.

Thus, for example, a fairly efficient ram having a fall of 10 feet, and forcing the water 50 feet high, if found forcing 5 gallons per minute and wasting 40 gallons per minute, will have an efficiency of $\frac{50}{10} \times \frac{5}{40} = 0{\cdot}625$

For a given fall the efficiency increases inversely as the height of discharge, or the discharge largely increases with a decrease of height.

A formula for regulating the weight of the waste valve to produce the maximum supply for the ordinary form of hydraulic rams has been proposed and formulated by an Austrian engineer, which may be of value for the adjustment of rams that are furnishing a deficient supply.

The formula is stated as: The area of the waste valve in inches × height of supply above the valve in feet × length of drive pipe in feet, and the product divided by 500 will give the weight, including the valve, for best effect, when the diameters of the drive

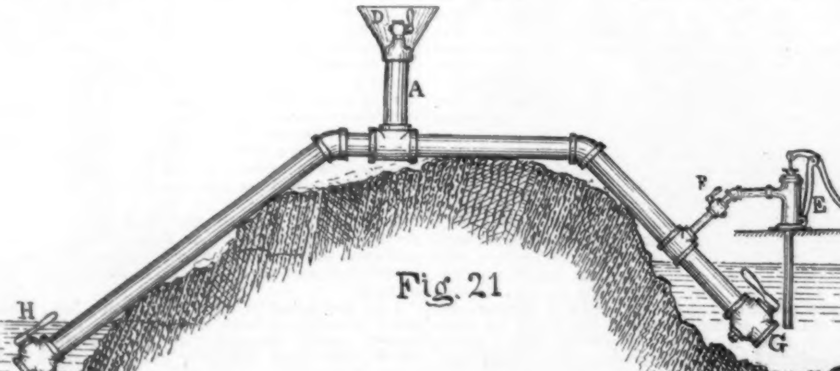


Fig. 21

and discharge pipes are of proper proportions. The formula may be expressed as $\frac{a' \times h' \times l'}{500}$ = weight in pounds.

For example, for a ram having a waste valve 2 inches diameter, in the clear opening, the area will be $2^2 \times 0{\cdot}7854 = 3{\cdot}14$ square inches, a fall of 5 feet, and drive pipe 40 feet long, then $\frac{3{\cdot}14 \times 5 \times 40}{500} = 1{\cdot}25$ or $1\frac{1}{4}$ pounds for the weight of the valve.

The drive or feed pipe should not be of less length than six times the height for a fall of from 6 to 10 feet; and for a less fall than 6 feet, from 8 to 10 times the fall in length, for best efficiency.

A fall of 2 feet in the drive pipe is as low as can be made to give satisfaction, unless by special adjustment and low discharge.

The discharge pipe should be from one-third to one-half the diameter of the driven pipe, according to length. There seems to be no reasonable limit to the distance that a medium or large size ram will discharge—even up to 2,000 or 3,000 feet, with a moderate elevation. For very long distances, it is better to have the discharge pipe larger than one-half the diameter of the drive pipe, to lessen friction.

The coupling attaching the drive pipe to the ram should have a snifting hole from one-sixteenth inch to one-eighth inch diameter, as shown at S. Fig. 22, drilled

Fig. 22

in a slanting direction toward the ram (if not provided by the makers), for the purpose of keeping the air chamber supplied by air. The momentary relief from the impact of the water in the drive pipe draws a little air in through the snifting hole and discharges it at the next impact into the air chamber. This is necessary to the continuous action of the ram, as the air under pressure in the air chamber is gradually absorbed and the efficiency of the ram is thereby destroyed.

The largest impact rams now made will under favorable circumstances supply from 60 to 70 gallons of water per minute, with elevation under 100 feet; say 86,000 gallons per day; enough for the largest stock farms, or for irrigating from 20 to 30 acres of land.

For irrigation purposes on a larger scale, see references in a previous chapter.

(*To be continued.*)

ON THE COMPOSITION OF BUTTER.*

By Dr. P. VIETH.

WHEN speaking about the analysis of butter, we are, at the present time, very much inclined to think exclusively of ascertaining whether the chief component part of butter, *i. e.*, the fat, consists of the pure fat derived from cow's milk. No doubt, the admixture of foreign fat to butter is a widely practiced and very serious offense, and the detection of such adulteration, with a view to put a stop to it, is a matter of the greatest importance. But over this prominent question we must not forget that there are other ways in which the purchaser and consumer of butter may be wronged. The remarks which I have to offer have some reference to the latter, and do not touch the former question of adulteration with foreign fats. My observations, moreover, are not addressed to the public analyst in particular, but to the analytical chemist in general.

We all are well aware of the difficulties to fix standards or limits of purity for natural products, such, for instance, as milk, but these difficulties also exist with regard to manufactured articles, those derived from milk, notably cream, if the term "manufactured article" is allowed to be used—and butter, forming striking examples.

When milk or cream is subjected to continuous dashing, the fat globules coalesce in consequence, it is assumed, of the fat constituting the globules passing from the liquid into the solid state. After churning has gone on for a time, conglomerates of fat make their appearance, and grow larger by continued dashing. The fatty mass thus obtained and removed from the liquid in which it floats—the buttermilk—is raw butter. In order to make of the raw product the article of trade it is necessary to remove part of the buttermilk inclosed in the raw butter, which is done by kneading the latter. The further treatment which butter receives differs with the habits of the various producing countries and the tastes of the consumers for which the finished product is intended. Thus, while in some countries kneading alone is resorted to as a means for the removal of the excess of buttermilk, in others this removal is done more effectually by washing the butter with water or brine. Again, certain kinds of butter, more particularly those made from sweet cream and intended for immediate consumption, contain no salt, or very trifling quantities of it, while others, those made from sour milk or cream and meant to be kept for some time, without exception have salt added, frequently in considerable quantities.

Salt is added to butter, not only to meet the taste of certain classes of consumers, but also as a preserving agent. Judging from the experience of others, as well as from my own, I am inclined to believe that the habit of adding other preservatives, notably those containing boracic acid, to butter is becoming very general in certain places.

One more extraneous matter frequently, perhaps one might say invariably, present in butter of commerce is some coloring agent. No doubt the coloring of butter originally arose out of a desire to give to all butter, which under certain circumstances is nearly as white as tallow, that rich yellow color which fresh grass butter is known to present, a kind which has the renown of being of especially delicate flavor. Nowadays, however, no one, when putting coloring to the milk or cream before churning, thinks of making appear like grass butter the white-looking product of the milk of his stall-fed cows. The reason why butter is colored is simply this: the trade demands an article which from one end of the year to the other should be as uniform as possible in every respect, and uniformity of color is one of the first qualities expected. Butter coloring is made exclusively of cake annatto, a harmless and clean preparation of the fruit of Bixa orellana, which has nothing to do with the nasty soft annatto preparation of by-gone times. The quantity of coloring used being extremely small, and its nature perfectly innocuous, there can scarcely be any reason to object to a practice which is nothing but a concession to the trade. The great importance which the butter trade has attained may be gathered from the fact that last year's import of butter into this country amounted to 1,927,469 cwts., worth £10,243,728, while the export was not quite 25,000 cwts. I am not aware of the existence of any statistics which would allow to state what the home production amounts to. It must, however, be very considerable.

I have mentioned that butter is frequently washed, in order to free it as much as possible from buttermilk; the complete removal of the latter, if intended, is certainly not achieved in practice. The kneading of the butter also does not rid it of all the buttermilk, or the water used for washing out the latter, as the case may be, and, indeed, a product consisting entirely of butter fat and containing no water would not be butter at all. On the other hand, the presence of an undue amount of buttermilk or water is not only highly undesirable, but may even be looked at as a fraud.

The question then arises in what proportion the various constituents should be present, and in the absence of any other guidance, I believe this question of standards and limits with regard to butter can only be satisfactorily decided by referring to the usual composition of butter as it appears in the market. The 267 analyses of butter samples which I have made in the course of the last few years might, perhaps, form a contribution to the solution of the question.

The way in which I proceed in analyzing butter is described in a few words: Into a conical flask of about four ounces capacity four or five grammes of butter are introduced. The flask is put in a drying oven, the temperature of which is kept at 100° C., and the evaporation of the water facilitated by giving the melted butter a circular motion every half hour. After the loss in weight has been ascertained, the fat is completely washed out with ether, and the insoluble part dried and weighed. In a watery extract of the non-fatty solids the chlorine is titrated. We have then determined water, fat, solids-not-fat and sodium chloride contained in the latter and calculated from the chlorine. The difference between the quantities of solids-not-fat and sodium chloride is made up by the small amount of the non-fatty solids of milk retained by the butter, and may, for convenience sake, here be termed "curd, etc." In case the butter should contain extraneous admixtures other than salt, for instance preservatives, so far as they are not soluble in ether, these would, of course, swell the last named item.

Turning now to the results of my analyses, I do not propose to harass you with all the figures relating to the 267 samples forming the basis of my observations, but will confine myself to giving maxima, minima, and averages for the various kinds of butters:

Description of Butter.	Number of Samples.	Fat.	Water.	Curd, etc.	Salt.
English, fresh and salt.... ...	72	82·97 to 90·49 86·85	7·85 to 14·39 11·54	0·02 to 1·55 0·59	0·00 to 2·44 1·02
French, fresh..................	108	82·83 to 86·61 84·77	11·63 to 15·57 13·76	0·46 to 2·17 1·38	0·00 to 0·51 0·09
French, salt.......	5	82·30 to 86·25 84·34	11·15 to 13·59 12·05	1·26 to 1·85 1·60	1·30 to 2·54 2·01
Kiel, salt.......	40	82·00 to 89·45 85·24	8·39 to 15·23 12·24	0·80 to 2·82 1·17	0·73 to 2·06 1·35
Danish, salt...................	17	78·05 to 87·57 83·41	9·58 to 17·25 13·42	0·94 to 2·39 1·30	1·06 to 3·05 1·87
Swedish, salt..................	25	78·91 to 85·64 82·89	11·78 to 16·06 13·75	0·77 to 2·01 1·33	1·12 to 3·00 2·03

With regard to the fat, I may say at once that I am of opinion that in a well-made butter it should not fall below 80 per cent. Among my samples there were three only in which the percentage of fat was below 80, viz., one sample of Danish butter with 78·05, and two samples of Swedish butter with 79·69 and 78·91 per cent. respectively. The extreme in the other direction was shown by a sample of English butter, which contained 90·49 per cent. of fat.

We have next to consider the quantity of water. An undue percentage of this should be objected to, if not for others, certainly for this reason, that it reduces below its proper limit the percentage of fat, which latter after all is what we chiefly want to buy in butter. On the other hand, the reduction of the water below a certain limit can be effected only by "overworking" the butter, a process which very injuriously affects the appearance and taste, and thereby the commercial value of the product. Moreover, in the case of salt butter a certain amount of water is required to dissolve the salt which has been incorporated into the butter, and keep it in solution.

The results of my examinations were as follows:

Percentage of Water.	Number of Samples.	Per cent.
7 to 8	1	0·4
8 " 9	6	2·2
9 " 10	6	2·2
10 " 11	16	6·0
11 " 12	39	14·6
12 " 13	46	17·2
13 " 14	103	38·6
14 " 15	38	14·2
15 " 16	10	3·8
16 " 17	1	0·4
17 " 18	1	0·4
	267	100·0

From this statement it appears that the percentage of water generally varies from 11 to 15, and that it rarely rises above 16, nor falls below 10. The samples of French butter are remarkable for their great uniformity in composition, which is explained by the fact that in Normandy large packing establishments exist which are supplied with freshly churned butter from a number of dairies, and make this butter up for the London market by blending and working it. In the samples of English-made butter the water was worked out more completely than in the remaining samples.

Speaking now on the item which I have termed "curd, etc.," I will exclude the samples of French butter, because some of them, at least, contained boracic acid. No preservative was found in samples of the other kinds of butter. The quantity of "curd, etc.," is of particular interest if considered in conjunction with the quantity of water present, as such consideration enables us to make some inferences as to the way in which the butter had been manufactured.

Milk contains for every 100 parts of water about 10 parts of solids free of fat. The same relation between the two items must exist in buttermilk and also in butter, provided the latter was made from sweet or slightly sour milk or cream and freed from the excess of buttermilk by kneading. If the butter, as is the fashion in some countries, is rinsed with water when taken from the churn, the relation referred to will be somewhat affected, and still more it will be disturbed if the butter is thoroughly washed with water or brine. The influences mentioned will, I need hardly say, reduce the relative quantity of "curd, etc." On the other hand, the relative quantity will be increased if butter is made from strongly acid material in which the casein had been not coagulated in soft, but precipitated in hard masses, which partially become inclosed in and are retained by the butter.

For every 100 parts of water there were present:

PARTS OF "CURD, ETC."

	Minimum.	Maximum.	Average.
In English butter.	0	13	5
" Kiel "	8	23	10
" Danish "	7	14	10
" Swedish "	7	16	10

We may consider, then, the Kiel, Danish, and Swedish butters not or very slightly washed—rinsed—and the English butters, in the majority of cases, very thoroughly washed. As an instance of a butter made of strongly acid material, I may mention a sample of Kiel butter in which the relation between water and "curd, etc." was 100 to 23; this butter had a decidedly "cheesy" taste.

The quantity of salt was very small in all the samples of fresh French butter, there being generally less than 0·1 per cent. present, proving that no salt had been incorporated into the butter. The same was the case with a number of the samples of English butter, others of the same class containing a few tenths of a per cent. of salt, pointing to washing with brine. Far the majority of samples of salt butter contained from 1 to 2 per cent. salt, a small number between 2 and 3 per cent., and one sample of Danish butter just above 3 per cent. I may mention that when salt is added to raw butter, about half its quantity only is retained by the butter, while the other half is lost in the buttermilk which is worked out.

In conclusion, I will apologize for having entered rather much into practical details which may, perhaps, be considered as in no way concerning the members of this society. My excuse is that I am of opinion that some knowledge of practical details is very frequently highly desirable for the chemical expert.

* A paper read at the meeting of public analysts, London, December, 1890.

A CURIOUS FORMATION OF THE ELEMENT SILICON.

By H. N. WARREN, Research Analyst.

DURING the preparation of specimens of crystalline and other forms of silicon, I obtained a most curious formation of that substance, which would appear, when tested analytically, to be composed of graphitoidal silicon, constituted so as to form most perfect and well-developed crystals consisting of oblique octahedrons. This peculiar form of silicon first made its appearance upon subjecting potassium silicofluoride to a most intense heat in contact with impure aluminum. Upon separating graphitoidal silicon thus formed by the aid of dilute acids, small quantities of the other substance were observed. Direct steps were at once taken to procure it, if possible, in larger quantities. After numerous experiments had failed to reproduce it, the following method was used with success, although still very uncertain. Graphitoidal silicon was first obtained by introducing pieces of metallic aluminum about the size of a walnut into a clay crucible of convenient dimension, and subjected to a heat sufficient to maintain in a fused state a mixture of four parts potassium silicofluoride, one of potassium carbonate, and two of potassium chloride. After the violent reaction attending the introduction of the aluminum had subsided, the crucible was urged to whiteness for about five minutes; after cooling and breaking the same a perfect round button, containing about 80 per cent. of silicon, was obtained. This, after carefully detaching any adhering slag, was placed in a plumbago crucible containing about twelve times as much aluminum as the button obtained, together with an addition of two parts of metallic tin, and covered with a layer of sodium silicate. The crucible and its contents were then subjected to the most powerful heat that could be obtained for about two hours; after cooling the same and breaking the piece of aluminum contained therein, the new modification was obtained in large perfect crystals possessing a full metallic luster and true models of oblique octahedrons. After dissolving the small quantity of aluminum mechanically entangled, the analysis of the residue showed pure silicon, insoluble in all acids except hydrofluoric, and infusible. In appearance the crystals resemble crystals of cast iron which are sometimes met with upon breaking a pig of that substance, the largest assuming a size of over half an inch across the faces, and as perfect as a crystal of alum.—*Chem. News.*

COST OF STEEL MAKING IN SPAIN.

THE manufacture of steel in Spain has given considerable concern to the Spanish government in connection with the production of equipment for the army and navy. Don Francisco Gascue has lately published a memoir on the subject, which contains some interesting data. The two districts considered are Asturias and Biscaya, the former the seat of the coal industry and the latter possessing the Bilbao ore deposits.

The cost of making Bessemer pig at Bilbao is placed as follows:

Cost of Bessemer Pig at Bilbao.

	Francs.
1,920 kilogrammes of ore at 7 fr.	13.44
422 kilogrammes of limestone at 2 fr. 75 c.	1.58
970 kilogrammes of coke at 26 fr.	25.22
Labor	4.50
Repairs and general expenses	3.50
Total	48.24

The manufacture of Bessemer pig at Gijon, Mieres and Felguera, and Quiros, in Asturias, is placed respectively at 58 fr. 34 c., 57 fr. 74 c., and 67 fr. 13 c. per metric ton. Basic pig at Mieres and Felguera would cost 52 fr. 74 c., making the cost of basic Bessemer 87 fr. 52 c., and of basic open hearth 96 fr. 61 c. At Bilbao the cost of making acid Bessemer at the works of the Société Altos Hornos, with two 8-ton vessels, single turn, is as follows:

Cost of Acid Bessemer Steel at Bilbao.

	Francs.
1,107 kilogrammes of pig at 48 fr. 30 c.	53.47
56 kilogrammes of spiegel at 1 fr. 70 c.	9.52
180 kilogrammes of coal at 20 fr. 50 c.	2.70
50 kilogrammes of coke at 26 fr.	1.30
Labor	3.95
Refractories	1.50
Moulds	1.50
Repairs and miscellaneous	2.00
General expenses	2.00
Total	77.74
Deduct 70 kilogrammes of scrap at 48 fr.	3.36
Cost per metric ton	74.38

The cost of acid open-hearth is placed as follows:

Cost of Acid Open-hearth Steel at Bilbao.

	Francs.
537 kilogrammes of pig at 48 fr. 25 c.	35.90
536 kilogrammes of iron scrap at 72 fr.	38.50
25 kilogrammes of steel scrap at 60 fr.	1.50
12 kilogr. of ferro-manganese at 330 fr.	3.96
95 kilogrammes of ore at 10 fr.	0.95
Labor	6.00
Moulds	1.50
Refractories	1.60
Repairs and miscellaneous	3.00
General expenses	2.00
Total	96.22
Deduct 25 kilogrammes at 60 fr. per ton	1.50
Cost per metric ton	94.72

PAPER gas pipes are made from strips of manila paper in width equal to the length of the pipe to be made. This is passed through a vessel filled with melted asphalt, and then wrapped around an iron core until the desired thickness is obtained. The pipe is then subjected to powerful pressure, after which the outside is strewed with sand, and the whole cooled with water. The core is removed, and the inside coated with a waterproof composition.

POLARIZATION WITHOUT A POLARIZER.

I HAVE accidentally made a quite useful discovery, which I have not seen mentioned before. In order to *polarize*, we put a polarizer (Nicol) beneath the stage and an analyzer (Nicol) above the objective (either right next to it, at the end of the draw tube, or above the eye piece). The selenite comes on top of the polarizer. Now, I found that the polarizer is not absolutely indispensable. Given a certain polarizing condition of the sky (*i. e.* blue, with more or less watery vapor—as either before or after a rain, snow, or fog), you can polarize very nicely with the *analyzer alone*, and, if you want display of color, put the selenite on top of the slide, or anywhere convenient to you—so it comes beneath the analyzer. The colors (and crosses) will, of course, be somewhat fainter than when you use the polarizer too. In order to get the best display, it will be necessary to rotate both analyzer and selenite until in the proper relative positions; or, to speak more correctly, the relative position of the P. A. of the selenite to the beam of light from the mirror decides the more or less intense coloration. With any other sky the polarization is not observed.

This observation is useful in so far as to enable the possessors of microscopes, without substage facilities, to polarize fairly well—under the circumstances—and the proper condition of the sky is often obtained in our latitude.—*H. M. Wilder, in Amer. Jour. Pharmacy.*

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